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ABSTRACT

College students need a learning environment that encourages them to develop their reasoning abilities, as well as to master course content. This booklet discusses an attempt to create such an environment: the ADAPT program at the University of Nebraska. ADAPT, Accent on Developing Abstract Processes of Thought, is a comprehensive, interdisciplinary approach that introduces freshmen to university work expectations. The program is based on Piagetian theory and includes courses in anthropology, economics, English, history, mathematics, and physics. Following two introductory chapters on Piagetian theory, nine chapters describe various aspects of the ADAPT program, and two chapters provide evaluations of the program. (RL)

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ADAPT

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A Piagetian-based Program

for

College Freshmen

University of Nebraska-Lincoln

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Dedicated
to
Jean Piaget, whose research findings and theoretical work
provided the foundation for the ADAPT program
and to
Robert Karplus and John W. Renner, whose work
in assessing student reasoning skills
and
in applying Piaget's theory to science teaching
served to guide our efforts.

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Prologue

How can my college teaching be made more effective? A few years ago, several of us at the University of Nebraska-Lincoln were struggling with that question. During that time the work of Piaget and the studies of the reasoning skills of American college students were brought to our attention. From those results the ADAPT program was developed.

We came to believe that the reasoning skills typically used by many college students are not appropriate for college courses. College students need a learning environment that encourages them to develop their reasoning abilities as well as master course content. Because we believed that advanced reasoning skills were common to all disciplines, we sought to formulate a program that encourages students to use their reasoning skills in one discipline as well as another.

The ADAPT program is a Piagetian-based, multidisciplinary freshman program. This program includes courses in anthropology, economics, English, history, mathematics, and physics. This program is designed to be a complete freshman year program of 30 semester credit hours at the University of Nebraska. Each student is required to take all of the ADAPT courses. Each student has about twenty class hours each week as well as a one hour seminar.

The ADAPT classes are based upon a learning cycle model that begins with the student's exploration of a variety of concrete experiences. From these experiences the students are helped to define words and invent concepts. Then the invented concepts are applied to a variety of other experiences. Experiences, rather than textbooks, form the central core of the ADAPT curriculum.

The ADAPT classes stress the importance of learning from other students. Many small group learning activities are carried out in the ADAPT program. The students have close contact with their peers and with their professors.

The ADAPT course content is determined as much by its usefulness in promoting reasoning as by its importance in the content scheme of the discipline. The content of the various courses is coordinated so as to reinforce the important reasoning skills used in each discipline.

This was a new experience for most of us. We were free from the content imperatives of our discipline. We were trying to coordinate our content with the content to be covered in other disciplines. We were selecting content on the basis of its importance in furthering the cognitive development of the students. We were centering our courses upon personal, concrete experiences,

rather than upon textual material. We have learned much in this process.

This booklet is our attempt to share with you what we have learned from the ADAPT program.

R.G. Fuller

CHAPTER ONE

Piaget's Theory and College Teaching

C.A. Tomlinson-Keasey

The influence that Piaget's theory has had on the understanding of cognitive development is incalculable. One can look at the establishment of the Jean Piaget Society, the publication of literally hundreds of books that deal with Piagetian theory, and the dominance in professional journals of articles related to Piagetian theory as some indication of the immense impact that this theory has had on the study of the child's acquisition of knowledge.

In the last decade, the force of Piaget's theory has spilled over into other areas, most notably education. Such books as Thinking Goes to School: Piaget's Theory into Practice (Furth and Wachs, 1974); Discovering Piaget: A Guide for Teachers (Gorman, 1972); and Piaget for Teachers (Furth, 1970) suggest that Piaget has something important and practical to say to the educational community. The fact that Piaget-based programs have mushroomed and educators have begun to use Piaget's theory to help teach specific and troublesome content areas [A Study of Concrete and Formal Operations in School Mathematics: A Piagetian Viewpoint Collis, 1975; and How Children Learn Mathematics: Teaching Implications of Piaget's Work Copeland, 1970] indicates that educators from a variety of levels and disciplines have begun to examine Piaget's theory. It is, however, only very recently that college and university professors have looked toward Piagetian theory for relevant and practical suggestions about how to maximize college student learning.

There are some good reasons for the tardiness of the college community in examining Piagetian theory. Initially the writings of Piaget focused on the age period from 11 to 16 as the final stage of cognitive development. It was believed that the child during this period was able to abstract from concrete experiences and to theorize about the total possibilities or alternatives that could be explored in any situation. It has, however, become clear that the transition to abstract or formal thought is not usually completed by the college years. Several studies indicate that as many as 50 percent of our college freshmen are not capable, much

less facile, with formal operational thought processes (Tomlinson-Keasey, 1972; Wason, 1968; Lovell, 1961; Karplus, 1974). Further, the evidence that the acquisition of formal operational thought processes continues throughout the adult years continues to mount (Tomlinson-Keasey, 1972; Piaget, 1972). One can speculate on the basis of the above that instruction during the college years might well serve to maximize this final stage of cognitive development.

Before one can consider maximizing intellectual growth, however, it is necessary to chart the course of cognitive development. Hence, a brief sojourn into the stages of intellectual development as outlined by Piaget is necessary. A stage of intellectual development refers to a period when a person's activities and reasoning are characterized by certain common features. The last two--concrete operations and formal operations--are particularly interesting to college educators.

An infant begins to know the world by touching and feeling things. He has no words or symbols to make those things meaningful. The main way information is obtained is by interacting in a very physical way with the environment. For these reasons this period is called the sensory motor stage. As the child begins to acquire language, around age two, objects that have been experienced in the sensory motor stage of development are named. With the ability to name or label objects, the child enters the stage of intuitive or pre-operational thought. After a child has attached symbolic meanings to objects, he is able to move into the concrete-operational stage. Such a child is no longer limited to dealing with objects in a perceptual or physical way. The many symbols which are referents for objects can now be manipulated in a logical way. Thus, it is possible to form a class of animals, for example, which is composed of dogs, cats, dinosaurs, birds, etc. Further, any particular class might be composed of several subclasses. If a child was limited in his operational ability to sensory motor or pre-operational kinds of thought, then he could only react to a dog as one object, a dog. If, however, symbols are available, and those symbols mean something, then those symbols can be transformed so that the object, dog, can become an animal, a mammal, a Cocker Spaniel, and Prince simultaneously. The abilities gained in concrete operations allow the child to begin transforming information logically.

The stage of formal thought which begins somewhere between 11 and 16 years of age allows the child to abstract even further from concrete experience. In the concrete stage the child could simultaneously put an object in multiple kinds of categories. Moving from these concrete kinds of labels, the child in the stage of formal thought can now reason about objects which cannot be seen or experienced concretely, such as the principle of inertia. The

most dramatic change from concrete to formal operations is evidenced in a shift from focusing on the realities of the world to a consideration of the total possibilities that might exist in the world. In fact, once formal operations are attained, the actualities of the world are secondary in a person's thought processes to the range of possibilities that might exist. For this reason, thought is much more flexible. An example of this is the adolescent in the university who has experienced a democratic political system his whole life. That experience constitutes his concrete understanding of a political system. However, when he reaches the formal operational stage, he is no longer limited in his thinking about political systems to the consideration of a democratic state. Hence, he can consider, and in some cases embrace, political idealizations that he has never experienced. He might become a Maoist or talk about the advantages of a socialistic state or a totalitarian state, or even an anarchistic state. In this example, the child's concrete experience places limits on his ability to think about the total possibilities. However, when he is able to deal formally with all of the possibilities, his thinking about politics may change radically. Another example is the development of moral or religious attitudes. A child whose religious experience has been an affiliation with the Catholic faith, might, when she goes to college, suddenly be struck by the plethora of possibilities other than the Catholic religion. Hence, she might study Buddhism or Judaism, or a variety of other approaches to moral and religious questions. Occasionally this kind of revolution in thinking troubles parents and teachers, yet it constitutes one kind of hallmark that the child is beginning to move from concrete experiences to a consideration of the total possibilities.

To summarize then, the characteristic differences between the concrete operational and formal operational periods are the individual's ability to consider the total possibilities in a problem. In time, the possibilities begin to transcend the actual. In addition, the individual is capable of and indeed prefers propositional logic to the earlier reliance on the empirical information available. In some sense, the individual substitutes postulates for his earlier reliance on symbols and objects. Finally, the individual can recognize and interpret functional relationships.

Most university professors have encountered students whose academic work seems to suggest that they are relying heavily on concrete operational thought patterns. Trying to teach students using such thought patterns to be analytical, logical, and critical constitutes a major and exciting challenge to college professors. The ADAPT program is one attempt to meet that challenge.

Before instituting a program based on Piagetian theory, one must have some indication of how a student progresses from concrete operations to formal operations. The mechanism suggested by Piaget is called self-regulation. Self-regulation occurs when a student is engaged in learning. When experiences and encounters confirm ideas or beliefs that have been held in the past, then these ideas and beliefs are stabilized. But when experiences tend to disconfirm a student's ideas, these ideas must be reorganized to deal with the conflict. Such conflict is an impetus for growth and change and leads to a new, more highly differentiated and stable set of ideas. The regulation that occurs is the constant monitoring that a student does of his own ideas and the new ideas that are being presented.

This, then, is the process whereby a student grows. Information that does not fit with the way a student is dealing with the world and serves as a disconfirming case for the categories and principles used forces him to gradually change and adapt to the new information. Obviously, however, students and adults never have categories or ways of organizing the world that are completely satisfactory. In every instance, new information, or information that doesn't fit a student's concepts or an adult's concepts, can serve as an impetus for further growth. It follows that it is possible for a person to be in a stage of formal thought in relation to one content area and still be in a concrete operational stage in another area. Those areas in which a student would most likely be concrete operational would be the areas of least experience. The expectation is that students approaching the content of economics for the first time, for example, would have a very global and undifferentiated set of concepts about economics.

Likewise, it should be clear that the stage of formal thought is really an adult mode of processing information. One continues to develop formal thought patterns throughout his lifetime in terms of deepening his understandings, broadening the domains of his experiences, and adding new intellectual fields or content areas to his experience. Finally, it follows that the quality of the abstractions that one forms in a particular area are to some extent dependent on the kind of conceptual or concrete information that is present.

Having considered, theoretically, the stages of intellectual development and the process by which development occurs, we can proceed to the implications that these principles have for college teaching practices. The first rather obvious point is that one must begin with material which is meaningful to the student. This often means beginning at a fairly elementary level. When new ideas and experiences are presented in a way that is partially consonant with the student's past experiences, the possibilities for growth are maximized, as is the likelihood that these experiences will be

incorporated into a new and stable set of concepts about the specific content area.

A second implication of Piaget's theory focuses on the self-regulation that takes place in the student. The clear point of a self-regulatory model is that the learner must be considered in all phases of planning and instruction. This puts an enormous burden on college instructors who genuinely want to present material that students can use. The learning cycle is one way of dealing with this problem and has served as a model in the ADAPT program for how to encourage students' participation. The actual courses in the ADAPT curriculum all begin with an exploration phase in which students are required to observe a behavior or phenomena and collect data about that phenomena. Following such exploration the data are organized and are used to form hypotheses, to provide a basis for introducing concepts which are important to the field, and to provide a basis for generalization to other topics. With the background provided by exploratory activities, students are prepared to deal with some of the theories and empirical findings related to a phenomena.

Of course the learning cycle doesn't always progress smoothly from one point to another. What happens, for example, when exploratory activities do not lead to the conclusions or concepts that are envisioned by the professor? When do you intervene in what might seem to be aimless exploration and start imposing your own classification system on the student? The points of intervention and the timing of intervention seem to be a delicate matter.

Translating Piagetian theory into the exploration, invention, and discovery phases of the learning cycle (Karplus, 1974) creates other problems. Exploration takes time and whereas the topic, revolution, might have consumed two lectures before, you cannot explore and then discover revolution so quickly. It seems probable, then, that exploratory activities will mean that some content is sacrificed. Whether students will have suffered from this reduction in content remains to be seen. Studies indicating that students tested on a lecture one week later recalled only 17 percent of the lecture's content (PIPSE, 1975) suggest that the amount of material covered is not necessarily correlated with the amount a student learns. If an approach like the learning cycle can engage students in thoughtful acquisition of knowledge, the loss of some content might seem less critical.

In summary, the most sophisticated thought patterns are not fully developed in college students. Further, if Piaget is correct, the way to develop these processes is to begin with concrete experience and proceed to more and more sophisticated abstractions. A final ingredient that should maximize student

learning is allowing the student's own thought processes to guide the search for knowledge. While these principles defy direct translation into specific classroom experiences, they can serve as a basis for a multitude of classroom activities. More importantly, they can form an approach to college instruction whose aim is a student with an integrated fund of knowledge that can be logically transformed into the advances of tomorrow.

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CHAPTER TWO

A TEACHER'S GUIDE TO THE LEARNING CYCLE

A Piagetian-based Approach to College Instruction

T.C. Campbell and R.G. Fuller
examples by
M.C. Thornton, J.L. Petr,
M.Q. Peterson, E.T. Carpenter,
R.D. Narveson

I. EXPLORATION

Suppose you are preparing to teach a new college course this year. Assume that this course is designed to serve students who have career goals other than to become college professors. We would like you to consider what teaching strategies you will use to teach such students. Please write down your responses to the following questions:

How do you select the content to be covered in the course? If you have decided upon the content, how do you decide among the various teaching methods such as lecture-recitation, discussion, group projects, Keller Plan (or PSI), or audio-tutorial schemes?

How do you evaluate the preparation of your students for this course?

If you find that they have the content prerequisites for your course, how do you know that they possess the reasoning skills that you will demand?

What activities can you use to help your students improve their reasoning skills?

What evidence do you have that your course will assist students in improving their reasoning skills?

II. INVENTION

We know that in order to increase one's learning, one must be able to perform a wide variety of mental operations. Examples of some of these operations are excluding irrelevant data, using simple scaling factors (ratios) and formulating the existence of an intermediate step to reach a final answer.

How do you know that your students have developed the ability to perform such mental operations? If they have not, can you select a teaching strategy that will help students develop competence in these mental operations?

Jean Piaget and others (Inhelder and Piaget, 1958) have studied the development of logical thought in children and adolescents and have proposed a developmental model to explain the growth of logical thinking in humans. Recently Karplus (1974) has suggested a Piagetian-based classroom instructional strategy that may assist students in their development of logical thought. This flexible strategy is called the Learning Cycle and provides some guidance for instructors who wish to combine the development of reasoning with the mastery of content.

The Learning Cycle is divided into three major phases known as Exploration, Invention, and Application (sometimes called Discovery). The general characteristics of each phase of the Learning Cycle are-

Exploration - Following a brief statement of topic and direction, students are encouraged to learn through their own experience. Activities are supplied or suggested by the instructor which will help the students to recall (and share) past concrete experiences and to assimilate new concrete experiences helpful for later Invention and/or Application activities. During this activity the students receive only minimal guidance from their instructor and explore new ideas in a spontaneous fashion.

Invention - In the invention phase the concrete experiences of the exploration are used as the basis for generalizing a concept or for introducing a principle. Student and instructor roles in this activity may vary depending upon the nature of the content. Generally, students are asked to invent part or all of the relationship for themselves with the instructor supplying encouragement and guidance when needed. This procedure allows the students to gain confidence through familiarity with the concepts introduced.

Application - The application phase allows each student an opportunity to directly apply the concept or skill learned during the invention activity. Application provides the students with additional broadening experiences. They use the invented concepts in different concrete settings.

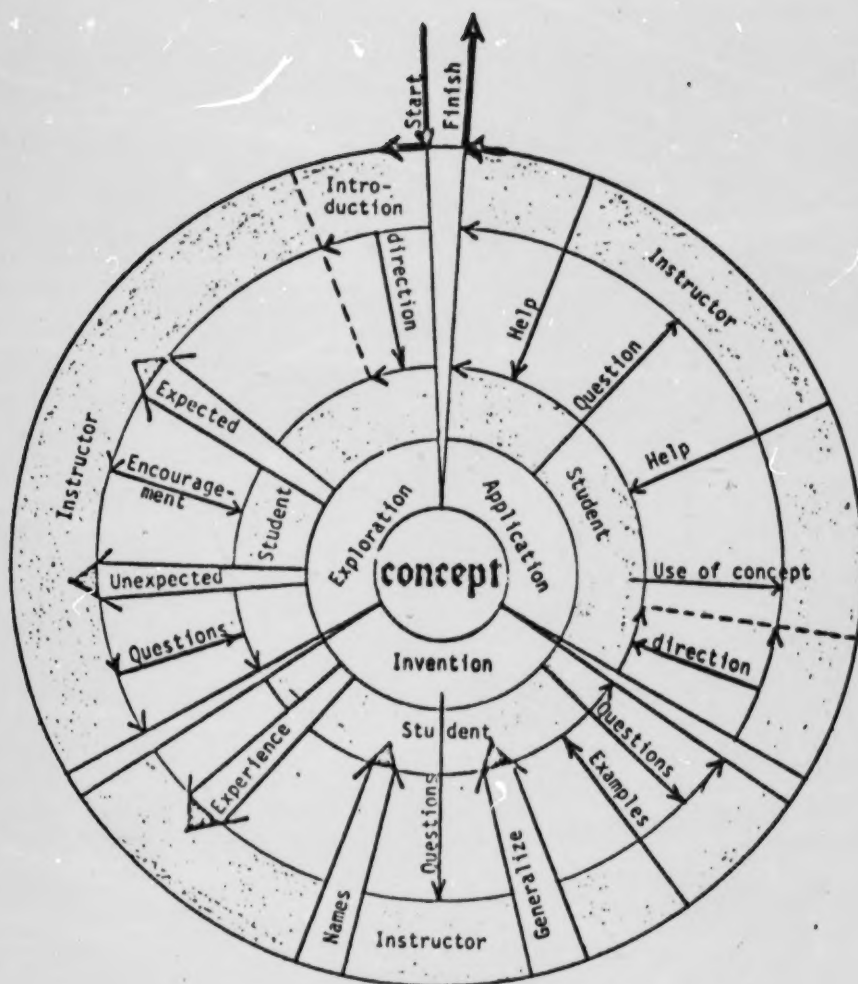


Figure 2. Learning Cycle model illustrating student and instructor interactions during each of the activities of the Learning Cycle.

The Learning Cycle allows each student the opportunity to think for himself. The instructor is a present overseer of activity. Yet he must guard against overplaying his role as director and facilitator. He must provide an open classroom atmosphere within a well-defined boundary.

The Learning Cycle offers you a model for designing instructional activities which may encourage your students to develop their reasoning skills and to learn concepts. In the following portions of this paper we offer some details of the Learning Cycle, its applications, and our guidelines for using the Learning Cycle to design classroom activities. The outline below describes the three parts of the Learning Cycle in detail.

A. Exploration

Emphasis - Concrete experience with familiar objects and systems.

Focus - Open-ended student activity.

Function - Student experience is joined with appropriate environmental options not previously considered by the student.

1. This phase of the Learning Cycle provides students with reinforcement of previous concrete experience and/or introduces them to new concrete experiences related to the Invention objectives.

2. Exploration allows for open-ended considerations, encouraging students to use concrete experiences to consider new ideas.

3. During Exploration the instructor supplies encouragement, provides hints, asks questions, and suggests alternatives. The instructor should encourage students to try a variety of experiments.

4. Student behavior during Exploration provides information concerning the student's ability to deal with the concepts and/or skills being introduced. The students will reveal the reasoning skills which they evoke in search for the solution to a problem.

B. Invention

Emphasis - Generalization of concrete experiences and abstract possibilities.

Focus - Student's active involvement with instructor for generalization.

Function - Students become familiar with generalized concepts and/or skills.

1. During Invention students are encouraged to formulate relationships which generalize their new ideas and concrete experiences.

2. The instructor acts as a mediator in assisting students in formulating these relationships to be consistent with results of their exploration activities.

C. Application

Emphasis - Relevant use of generalized concepts and/or skills.

Focus - Directed student activity.

Function - Further use of generalized concepts in other systems.

1. To begin the Application, the students and the instructor may interact in planning an activity for applying the invented concept and/or skill. The activity should provide a new or unique concrete situation.

2. Students are asked to complete the designed activity to the satisfaction of the instructor. The activities should provide further experience which will act as broadening and stabilizing experiences related to the new skills or concepts.

III. APPLICATION

The ADAPT program at UNL is an experimental, multidisciplinary program for freshmen. The intervention strategy utilized by this program is founded on Piagetian principles. The instructors involved in the project utilize the Learning Cycle model in planning their class activities. The examples which follow are taken from ADAPT experiences. They are representative of classroom activities which have proven to be successful in terms of improved student reasoning. (Campbell, 1976).

Physics Learning Cycle Example

A. Instructional Objectives

The objectives of this intervention are to

1. introduce students to the general properties of periodic motion and to a subset of systems which illustrate simple harmonic motion.

2. provide appropriate symbols and names for the variables used in discussing simple harmonic motion.

3. invent a mathematical relationship between mass, period, and amplitude for a system which vibrates in simple harmonic motion.

E. Exploration Activity

Name _____
Lab Partner _____
PERIODIC MOTION
<u>Exploration Activity</u>
On various tables in the lab you will find systems which oscillate periodically when displaced from their rest (equilibrium) positions. The type of systems include the following:
A. Rolling motion (weighted cylinders)
B. Bobbing motion (long flexible rods)
C. Vibrating motion (mass vibrated by fixed hacksaw blades)
D. Swinging motion (cylinder hung on fixed support)
Please investigate the properties of as many of these types of periodic motion systems as time allows. As you observe them, look for and identify the following characteristics:
1. Physical variables which are present in each of the systems.
2. Physical variables which can be controlled (held constant) while other variables are allowed to change.
What experiments could you design to investigate the properties of the systems above? What data would you collect and what methods might you use for analysis?

Rationale: Many students involved in this activity have had experience with oscillating objects: Fish bobbbers, swings, pendulum clocks. Most, however, have not considered the properties of systems which illustrate simple harmonic motion. Concrete experience is expanded by providing familiar and unfamiliar systems for exploration. Students are encouraged to explore by changing variables within a single system. A cognitive challenge is provided by asking students to compare common controllable variables found in each system. The exploration is designed to provide needed concrete experience for the Invention activity. Students who finish their exploration early are given the invention sheet below and encouraged to invent many of the concepts on their own.

C. Invention Activity

NAME _____
PERIODIC MOTION
<u>Invention Activity</u>
1. List the characteristics of the various systems which were different.
2. List the characteristics of the various systems which were similar.
3. What experimental tools could be used to investigate the nature of the similar characteristics of the systems listed in 2 above? What does the experimenter do about the other variables of the system?
4. What mathematical and/or graphical tools could be utilized in investigating the relationships between period, restoring force, amplitude, mass and/or length for each of the systems that vibrate. How would you set up an experiment for collecting the data needed?

Rationale: In beginning the invention, the instructor requires that students discuss the results of their exploration. This interaction provides a check on student progress and indicates a readiness to begin the invention phase.

The invention activity allows for instructor leadership in assigning common symbols and names to variables the students explored. Then, depending on students ability, the relationships between force, displacement, mass and period can be introduced. Before completing the Invention, the instructor should provide an example showing how each of these variables influence one of the systems investigated during the exploration activity.

D. Application Activity

NAME _____
LAB PARTNER _____
PERIODIC MOTION
<u>Application Activity</u>
Your lab instructor will provide you with apparatus for another oscillating system, the rubber band-mass system.
Equipment: 1 rubber band 1 meter stick 1 set of metric masses 1 support rod 1 timer
Carefully design and perform an experiment which will provide the following information about this system:
A. Force (measured in grams) needed to stretch the rubber band through some given distance. (Are there any limitations to this measurement?)
B. Force constant of the rubber band in grams/cm. Is this constant always constant? (Hint: Plot a graph showing displacement (x) vs. grams of load (y) and take the slope of the graph.) Is the graph linear?
C. Period of oscillation as a function of the mass of the oscillating object.

Rationale: The application activity requires the students to directly apply the invented relationships between amplitude, mass, displacement, and period. The activity may center upon one of the examples used for Exploration but is more effective if it is a new apparatus such as the rubber band oscillation shown above. This activity serves to broaden students learning by providing a system where they can directly apply the invented concepts.

Mathematics Learning Cycle Example

A. Instructional Objectives

1. to review addition, subtraction, multiplication, and division of signed numbers, fractions, and decimals.
2. to review the commutative and associative laws of arithmetic.
3. to practice making and testing conjectures.
4. to discover and apply a formula for the sum of an arithmetic series.

E. Exploration Activity

1. Presentation to class: Here is an example of what can be called a 3 x 3 box puzzle. A square is divided into nine regions; two odd and two even numbers are placed in the four upper left regions as shown.

2	3	
5	-6	

The first two rows can be completed by addition. The first two columns can also be completed by addition. Now the lower right corner could be reasonably completed as the sum of the third column or the sum of the third row. In this case either method gives the same answer, 4. So we say that this 3 x 3 box puzzle "works".

2	3	5
5	-6	-1
7	-3	4

2. Exploration in class.

- a) Try a couple more 3 x 3 addition box puzzles starting with two even and two odd integers. Do they also work?
- b) How could such box puzzles be changed? Suggestions by students included: use different numbers, drop even-odd requirement, use a different operation (e.g. subtraction, multiplication), use different sizes (e.g. 4 x 4, 5 x 5), and use a different shape (e.g. 3 x 8).

3. Exploration as homework.

The exploration of box puzzles was continued as homework using the assignment shown.

Math Homework - Exploration Activity

1. Work these addition box puzzles:

a)

$1+2$	$1+2$	
$-1+2$	$1+2$	

b)

$\frac{1}{3}$	$\frac{3}{5}$	
$2\frac{1}{3}$	$-\frac{5}{12}$	

c)

1	2	3	4	5	
5	4	3	2	1	

d)

a	b	
c	d	

Here a,b,c,d are all numbers

2. Will 3 x 3 box puzzles work using mult?, subtraction?, division?
Support each answer with two examples one using fractions and one using decimals.
3. Work these two box puzzles using addition on the rows and mult. on the columns:

Example

1	2	3	$1+2$
3	-6	-3	$-3+(-6)$
3	-12	-3	$-3-12$

$1 \times 3 \quad 2 \times -6 \quad 3 \times -3$

3	-2	
-6	-4	

10	5	
-6	8	

4. What do you conjecture about row-addition, column-mult box puzzles? How can you test your conjecture? Try it.

C. Invention Activity

The homework exercises were discussed the following day. In problems three and four most students guessed that such puzzles always work and then discovered an example which did not work. These examples bothered three students enough so that they hunted for and found necessary and sufficient conditions for such puzzles to work.

When directed to choose $c=0$ in problem 1d) and use parentheses carefully, the class recognized the associative law for addition. Choosing $a=d=0$ produces the commutative law.

Several other $3 \times n$ addition box puzzles similar to 1c) were worked until the class noted that an arithmetic series in the first row and the same numbers backwards in the second row gives the same sum in each column. Thus the final answer is the column sum times the number of columns. But this answer is also the sum of the first row and of the second row, that is twice the sum of the series. So the formula for the series sum was derived and related to the "average value times the number of values" formula many of the students had seen before.

D. Application Activity

Assigned homework problems asked the students to:

- a) obtain the associative and commutative laws of multiplication from a 3×3 multiplication box puzzle.
- b) obtain the distributive law from a special hybrid box puzzle.
- c) apply the formula for the sum of an arithmetic series to various other problems.

Two months later, on the final exam, the students were asked to find the sum of all odd numbers between zero and one million. Without further class time on this topic 49% found the sum, 39% used the box puzzle approach but missed some of the details, and only 12% had no idea how to begin.

Economics Learning Cycle Example

The following is an example of implementation of a learning cycle approach to economic studies.

Development of a College Student Price Index (analogous to the Consumer Price Index) is one "real world" activity which economics students have accomplished and which exemplifies several of the pedagogical components implicit in Piaget's work. Particularly during an inflationary period, a device which can help them see the shape and size of inflation as it affects them is of interest to students.

The exploration phase of this learning cycle involved two components. One was collection of data from the students themselves to determine what they bought and what they spent for

it. This data emerged from a record the students were asked to keep for a period of two weeks listing all purchases and amounts expended. The second exploration component was gathering price data from the shelves of Lincoln merchants.

Many "inventions" or kinds of concept formation were necessary to complete construction of a respectable price index. One "invention" centered on the concept of a representative market basket of students utilized commodities. It was, of course, apparent to students that we could not manage an index which contained every conceivable purchase during the school year. Thus their own records of purchases made were used to generate a list of 65 commodities, selected by the class to represent their buying activity.

The students were soon confronted by the fact that simply adding up the prices of the selected commodities during two time periods and comparing the results was not sufficient as a representation of changes in their purchasing power. The importance of each item, or class of item in their budget needed to be considered; thus the idea of grouping the commodities into classifications and appropriately weighting each class was interjected. Six classifications were used (food, toiletries, school supplies, recreation, clothing and miscellaneous) and weights were assigned again based on their recorded expenditures over the two week period. (Housing was omitted because of the anticipated stability of dorm rates during the academic year.)

The necessity for developing standards and specificity in product selection quickly became apparent. Simply going to the store and pricing "soap", or "gasoline" was not good enough; and our list soon specified "Dial, 5 oz.", and "PX plus" gasoline. Thus the ideas of care and rigor in data collection, and the necessity of subsequent replication, were made tangible for the student (were invented).

Not to be forgotten among all the other inventions which were occurring is the concept of an index number itself. The students found indexation a useful concept to make some sense out of the mass of information gathered over a period of time, and it was regarded as a helpful aid rather than a teacher-imposed burden by the time it was used in class.

Finally, the application phase of this unit is nicely built in as the students were given the job of price gathering and index calculating at the first of each month. Thus we watched the index grow month by month, each calculation reinforcing work done earlier. Each month the movement of the components of the index is somewhat different; the effects of seasonal changes are apparent, and the students become more comfortable with this tool.

Disequilibration and self-regulation are a natural and unavoidable part of the process. Having student A price soap one month at \$.89 and having student B report it at \$.35 the following month led to the self-regulation of product specification and standardization. The idea of grouping and weighting grew from the disequilibrium caused by having the 10% change in the price of a pair of shoes completely overwhelm price decreases in small ticket items (such as toothpaste) when the entire list was aggregated in an undifferentiated way.

Anthropology Learning Cycle Example

Assignment:

What are the rules for saying "Hello" or "Hi" to a stranger?

(To answer this question, the student must observe, count, describe and then test in operation a whole series of non-verbal behavior that allow him/her to get the attention of a stranger--another student usually--and say "Hello" or "Hi" without seeming odd or peculiar. Especially important: the student has to be able to do this without stress.)

Exploration Phase:

The students go out in pairs, one greeting people, the other watching. At this time, most people trip up by observing too large of units of behavior: "I said Hello and he said Hello".

Invention Phase:

The students start to break down the "say Hello" package to a series of smaller, connected wants. One student observed that the following sequence is necessary:

- 1) Look at stranger.
- 2) Establish eye contact (How?)
- 3) Look down at ground briefly.
- 4) Look back at stranger.
- 5) If stranger makes eye contact, continue eye contact.
- 6) When between 6 feet to 3 feet apart, say "Hello".
- 7) With "Hello" or "Hi", nod your head.

8) Break eye contact.

Application Phase:

With this pattern established, the students then go out and try this pattern of behavior with persons of same and opposite sex, with different age persons, with different status persons and with various other non-verbal behavior, as, for example, smiles.

Comment:

The two most important aspects of this learning cycle are the detailed observations of the student and the possibility of applying the behavior sequence.

Logic Learning Cycle Example

Organizing instruction according to the learning cycle may be particularly effective in a course in which students must gain skills in application of a system of symbolic representation of ordinary language, such as a symbolic logic course. Where students are to learn to read and use propositional logic in a symbolic logic course and where the majority of those students are frightened of things that remind them of mathematics, it is extremely helpful to begin with what they are comfortable with--namely, presenting their reasons for their conclusions in their everyday English. From there they may extend one step at a time into the symbol language with much less frustration than if they are given the symbol system separately and forced to make their own connections between it and their own language.

Once students were introduced to the term "proposition" and were comfortable with the task of "picking out the propositions" from various examples of writing and speaking, my logic students had to become adept at recognizing the different sorts of expressions that indicate the five different logical operators which our symbol-system used. They were engaged in the following series of activities in order to facilitate their learning.

1) I asked them to suggest expressions they knew which are used to connect propositions in their ordinary acquaintance. They generated a list of 38 English expressions including the standard logic-teacher's ones such as "or," "and," "but," "if," and "therefore." This took about 15 minutes of class time. The words were listed on the board as they were suggested--later they were copied onto a ditto master so that each student could have a copy at the beginning of the next class hour.

2) Students divided into groups of about 5 persons each--
Instructions: Sort through the list of expressions and decide how to group them so that those expressions that seem to work alike are put in the same group (In deciding try to make up examples of propositions related by each of those expressions.) About 2 1/2 class-hours were given to their working in this stage.

3) Each group of students presented their way of grouping the list--telling why and giving their examples when their peers questioned them. Since there were 5 groups of students in the class, there were 5 schemes of classification. Each was put on the blackboard so all 5 could be referred to by the whole class. Sorting through the 5 schemes it was obvious that there were four main groups in each scheme and that a nucleus of expressions in some group of each scheme were similar--e.g., in each scheme, there was one group that contained at least "if," "because," "since," "therefore," and "so," and in each scheme was one group that contained at least "and," "also," "too," "but," "in addition," and "however." These similarities were found by the students who were encouraged. The four main groupings contained some expressions which the students tended to make into a subgrouping--they were expressions that combined the same sort of connection as the others of the group but also included a negative sense--e.g. "neither_nor__," and "not both." Noting this, attention was drawn to the ways "negation" worked in the examples given and how that made a difference in the sense of the regular (non-negative) connection.

4) Within each of the four main groupings, students selected an expression that they thought would be useful as a model with which to compare new-connectors they might come across. In this step the category of implication indicators became troublesome for them--they found a solution in making 2 subgroups: one containing the conclusion-statement or that for which the "reason" was offered. Thus, "Because," "Since," and "For" were put in one subgroup separated from "Therefore," "Hence," and "So."

5) Having generated the categories for the operations we would need to use in the propositional logic system they were to learn, names of and "official definitions" for the logical relationships between propositions used in the course were simply pronounced in terms of: "We will take these expressions as indicators of disjunction which is the relationship of alternatives between propositions--e.g., "this is so or else that is so." The operators we used were conjunction, disjunction, implication, double implication, and negation.

A total of about 4 class hours were given to this series of activities. That investment of time seemed later on to be well worth it because students gained a considerable security in

recognizing the logical connectors, differentiating them from one another, and of finding ways of handling the classifying of new examples that they encountered during the semester. This was a significant difference from what happens when students are presented the operators, their definitions, and expressions in ready made groups coincident with the operators to be used in the symbol-system and are expected, by doing exercises, to learn to differentiate them one from another. Using this last, traditional, method it commonly takes undergraduate non-math and non-philosophy majors at least four weeks (12 class hours) to achieve sufficient stability in their skills at operation recognition, and usually even then there will be some slow students who never get them settled for themselves. However in using the new method, in a class of 35 students, after the four class-hours in generating the categories and sorting things themselves, there were no cases brought up by students or by instructor which any student had trouble or was hesitant in deciding whether, e.g., if it worked like "and" which category it belonged in, etc. That's success!

English Learning Cycle Example

This learning activity is designed for a freshman English course stressing writing by students. The cycle described for the study of Fride and Prejudice requires at least three weeks of class time.

A. Instructional Objectives:

To appreciate the interaction of plot, character, and theme in causing us as readers to respond strongly as we read good fiction. We are not reading P and P to learn about plot, character and theme. Rather, in order to enhance awareness of what Jane Austen has put into the novel to engage our interest, we talk about specific actions, characters, and ideas found in this novel.

B. Exploration Activity

1. Two students take the roles of Mr. and Mrs. Bennet and read aloud the conversation in Chapter 1. Students react to Jane Austen's language. Ask students to state what the novel will be about, judging by this chapter.

2. Ask for three volunteers to write papers to be duplicated and discussed in group sessions the following Monday. (Regular paper-writing is required and students readily volunteer, since by now they have learned the value of lots of criticism of their papers, before they hand in the final version for teacher evaluation.) Topic of papers: Late in Volume One, Bingley, who had seemed to be falling in love with Jane, leaves Netherfield along

with his party, apparently not to return. We do not at this point in the novel know what Bingley's motives are for leaving, so we can only speculate. How do you as a reader react to this development; when you look back through the chapters of the novel leading up to it, what do you find that might influence your reaction?

3. Have students read aloud the letter from Mr. Collins to Mr. Bennet and the reactions of members of the Bennet family that follow. Lead a discussion exploring what students think of the various characters and the way these characters are talked about. As students mention various traits of character, list them on blackboard.

4. Since it was established in discussing the first chapter that the novel will be about courtship and marriage, students may now be asked to discuss what they think the characterizations and the comments characters make about each other have to do with marriage. To stimulate the discussion, ask students to help make a list of the couples in the book and to try to give a reason why Jane Austen has included each couple. Ask what the different characters think is important in a marriage. (On blackboard, write the list of couples and suggested reason for inclusion.)

c. Invention Activity

Monday. Divide into three groups. Each group discusses one of the papers with the writer, the students making written comments on their copies, suggesting to the writer what the strong and weak points of the paper are and how it can be improved. End session by asking students to mention something they learned during the session. It will typically emerge that 1) the writers claimed to have been caught by surprise when Bingley left, and 2) on reviewing the chapters leading up to his departure, they found all sorts of hints, that they had missed, that should have prepared them for this possibility. They will have found these hints in the conversations that show the importance in a marriage of property, family, and personal compatibility; in the occasions that permit the Bennet family members to display their silliness and "lack of breeding"; and in the traits of Bingley and Jane that could lead Bingley to take the action he takes. They will thus have become aware of the complex interaction of plot, character, and theme in shaping the response of an attentive reader, for they will either have been attentive readers themselves or have seen how much an attentive reader among them has observed.

D. Application Activity

1. Ask for three volunteers to write papers for class discussion on the following Monday. Topic: After Elizabeth has thought over Darcy's letter (following her refusal of his marriage

proposal) she exclaims, "Till this moment, I never knew myself." How do you react to this declaration, and what do you find in the book to this point that has conditioned you to react as you do?

2. Proceed as with first papers.

3. Repeat with a discussion of papers on a similar topic based on an incident in Volume Three.

It is, of course, understood that because reading a novel is a very complex activity, from which different readers carry away different impressions, the direction by the teacher toward a specific learning objective must be tactful and flexible. While students are learning to distinguish elements that contribute to creating novelistic effects, they are also learning to complicate their observations and their consequent judgments by identifying the variety of features of the novel, the variety within each feature, and the impingement of Austen's fictional world upon what they know of the historical period and place as well as upon their own time and place.

IV. ANOTHER EXPLORATION

We have attempted to present this article in a Learning Cycle. We asked you to explore how you plan to teach a college course (Exploration, Sec. I.). We invented the learning cycle concept for you (Invention, Sec. II). We applied the Learning Cycle to several examples of classroom work. (Application, Sec. III). We encourage you to try the Learning Cycle in your college teaching. Now it's your turn. Please pick a topic. Perhaps one you currently are teaching or one that gives students difficulty. Take a few minutes and consider how you will introduce students to the concept using the Learning Cycle.

V. ANOTHER INVENTION

Planning the Learning Cycle Activities

As the facilitator of classroom interaction you have the responsibility for planning the Learning Cycle activities: Exploration, Invention, and Application. When planning, you use your past experience to anticipate problems and difficulties that your students will have with each activity. Remember that while some difficulties are necessary if students are to learn, their reasoning capabilities must soon match the reasoning required to complete the tasks you ask them to perform.

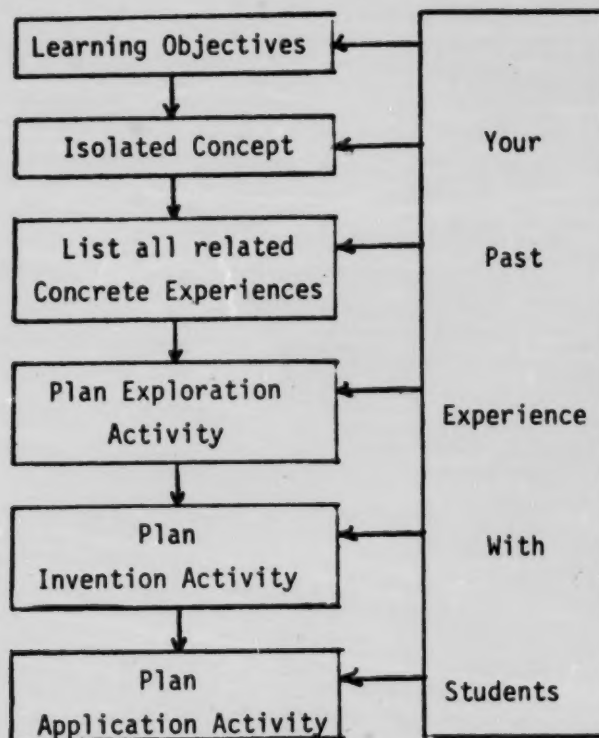
Your first responsibility will be to isolate a concept that you wish to introduce to your students. Next, you should list all

the concrete experiences which are associated with this concept; both those you expect your students to have had and those which you think are directly related to the concept to be introduced.

Now you are in a position to plan the exploration activity. Select from the list a wide variety of the concrete experiences which are relevant and ones that you can provide in a classroom. The exploration activity should provide students with a period of time when they are free to explore the systems which you have provided. Exploration will lead to spontaneous investigation, questioning, isolation of variables and a search for relationships.

Next, you can plan the invention activity.

The flow chart shown in Figure 1 summarizes the main features of your responsibilities in planning your learning cycle activities.



You should consider how the exploration activity will help your students to begin the Invention on their own. In discussion with your students you may suggest variables and relationships suitable to the explored system. Then with your help and assistance (either in groups or as a class) your students can solidify the generalization you have planned. Again, your past experience will assist you in being prepared to deal with the thoughts your students will have about the relationships they found during the Exploration.

Finally, the application activity will provide a direct use of the concepts invented. Students conduct further investigations with specific variables that have been isolated and seek to establish definite relationships among the variables. You may introduce new materials that permit investigation of the phenomenon in other contexts. For example, the characteristics of periodic motion can be invented after exploration of rolling, bobbing, twisting, and vibrating objects. Then experimental investigations of the properties of a pendulum will allow for concept reinforcement, refinement, and enlargement.

A positive benefit of the initiation of course content with the investigation of some concrete experience is that, in most cases, unexpected events will occur and questions will be raised that cannot be answered by looking in textbooks or lab manuals. Textbooks contain general answers. These experiences pose specific questions--questions that must be answered through specific inquiries.

Interactions During the Learning Cycle

Following your planning, you are ready to begin the exploration activity with your students. You should begin by giving minimal direction. This will get things started. Be careful that you do not give too many specific directions; allow the students to investigate on their own.

During the exploration you should observe what the students are saying and doing. Listen to their conversations. Watch their attempts. Consider the explanations they provide one another. They will arrive at unanticipated results. Do not reject these results, but encourage them to try other tests. Give encouragement to students who require your assistance but don't be willing to provide answers to all their questions. Let things develop on their own, within limits of your tolerance. As the exploration draws to a close, visit each student and look at his data, his results, and ask him a few questions about what he has concluded. During this time your students will tell you more about their reasoning skills than at any other time during the Learning Cycle.

Now you are ready to begin the Invention phase of the Learning Cycle. During the Exploration activity you have gained insight into how your students think about this concept. Now you must help them generalize the concept by meeting them where they are and by leading them to more advanced thinking. Encourage them to interact with one another. Try to let them have the feeling that they are inventing a new concept.

At the close of the Invention activity you may introduce the Application activity. The directions given for this activity should be more specific than those given during the beginning of the Exploration. While your students are applying the new concept, you should interact freely with them answering questions that they have about the activity. Slower students will need additional assistance because they may not have completely understood the Invention. Again you should be interacting with the students. The feedback which you get through the interactions with students during the application activity provides you with additional information about their ability to apply the new concept. A model illustrating student instructor interactions during the Learning Cycle is shown in Figure 2. (See Page 10a)

VI. ANOTHER APPLICATION

Please apply the concept of the Learning Cycle developed during this article to the teaching of a concept to your class. If you would like further examples of learning cycles that we have tried with college students, please contact us. Let us know about the learning cycles you use in your college classes.

REFERENCES

Campbell, T.C., "Proportional Reasoning In College Freshmen," unpublished, 1976.

Inhelder, B. and Piaget, J. The Growth of Logical Thinking From Childhood to Adolescence, Basic Books, 1958.

Karplus, R., Science Curriculum Improvement Study, Teachers Handbook, University of California-Berkeley, Berkeley, California, 1974.

CHAPTER THREE

The Details of the ADAPT Program For College Freshmen

The following paragraphs were taken from the brochure mailed to all prospective University of Nebraska-Lincoln freshmen. Forty students who expressed an interest in the ADAPT courses from the brochure were selected for the program. No attempt was made to select students on the basis of their previous school work or test scores.

DESCRIPTION

ADAPT is a special program designed for freshmen. It consists of special courses in various departments. Content from these courses is closely interwoven and makes maximum use of your own experience.

As an ADAPT student, you will work closely with experienced professors. Your classes will be much smaller than most freshman classes, and you will get to know your professors and your fellow students. Your advisor will be a member of the program so he will be able to discuss your program and goals with unusual understanding.

ADAPT men and women earn 15 credits each semester, like most full time freshmen. These credits will apply to group requirements in the Arts and Science College and most other colleges, so that you will be prepared to go on to advanced courses. Your adviser will help you divide your credits among the English, Mathematics and Logic, Natural Science (including lab), and Social Sciences requirements.

At the end of your freshman year you will be well on your way to satisfying the group requirements for the BA or BS degree.

PURPOSE

ADAPT stands for Accent on Developing Abstract Processes of Thought. A program unique in the nation, ADAPT is a comprehensive and coordinated introduction to expectations of university-level work.

Since many freshmen throughout the nation experience some difficulty in meeting their own objectives in university work and are often unsure of their own potential and their career plans, the ADAPT courses will stress the students' ability to develop sound reasoning skills while gaining information and insights into several major disciplines.

Persons who are exploring career opportunities as well as those who have already selected a major field will find the ADAPT program an ideal way to start their university education.

The ADAPT program is made possible by a grant from the Exxon Education Foundation. Exxon funds are only awarded to programs that hold promise of effective nationwide application. This program is another in a series of innovative educational programs at the University of Nebraska, Lincoln.

ADVANTAGES

Explore many fields of study before starting on your chosen major.

Meet in small informal classes with experienced professors.

Be in close contact with faculty members interested in your performance and welfare.

Share several of your classes with some of the same students and get to know them personally.

Take courses that fit together and build toward a common educational goal.

Total academic work is evenly spread throughout the semester. This means that ADAPT men and women will never have several tests on the same day.

ADAPT COURSES

You may not necessarily find these courses listed in the various college catalogs, or the First Semester Schedule of Classes, since these classes are for ADAPT participants only.

ADAPT requires twenty hours of classwork each week. Everyone in the program takes these special ADAPT courses:

English 198D	Anthropology 198D
History 197	Mathematics 198
Economics 198	Physics 198G

These courses apply to appropriate Group Requirements for graduation from most colleges in the university.

Specific registration instructions will be given after selection.

At the first meeting of the ADAPT classes a handout that gave the class schedule and stressed the interactive aspects of the ADAPT program was given to the students (see below).

The ADAPT program stresses activity centered learning. Your involvement in the total variety of classroom experiences provided in this program is essential. Many of the ADAPT classes will begin topics with open-ended, flexible exploration experiences. On the basis of what you and your student colleagues learn from these exploration activities, the ADAPT instructors will help you invent definitions and concepts and apply them to new experiences. In order to benefit from the ADAPT program, you should plan to actively participate in all of the scheduled ADAPT classes and seminars.

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	ROOM
9:30	Econ		Econ		Econ	110 Westbrk.
10:30	Eng		Eng		Eng	231 CBA
11:00		Anthro 37 And		Anthro 37 And		
11:30	Hist		Hist		Hist	11 Woods
12:15	xxxxxx	xxxxxx	xxxxxx	xxxxxx	xxxxx	xxxxxx
1:30	Math+Phys				Math-Physics	314 Ferg
2:30	Math	Seminar 11	Math		Math	308 OLDH
3:30	*Phys Lab	Woods			*Phys Lab	314 Ferg
5:00						

*certain days only

CHAPTER FOUR

Piaget and Learning Economics

J.L. Petr

There are times when teachers of economics encounter unexpected responses to economics questions asked of students. Some of the unexpected responses which I have received are reproduced below and are worth rather careful consideration.

* * *

Question: One year ago I could have bought a Volksunota (a small foreign car) for 4900 shebangoes (which my banker tells me equals \$3500). Now, however, due to inflation, a Volksunota costs 6300 shebangoes in its home country. Assuming the exchange rate (the rate at which shebangoes trade for dollars) has stayed constant, how many dollars would I now have to pay for a Volksunota?

Answers:

Student A--\$4900. \$3500 was \$1400 less than 4900 shebangoes. So I subtracted 1400 from 6300 shebangoes and got \$4900.

Student B--There is no way to tell. In the first case it cost 4900 shebangoes here, not in its home country, so you have to consider import taxes and export taxes, etc., plus cars usually sell much cheaper in their own countries. Even if the rate of exchange is the same, there may be more taxes in the home country you don't know about.

Student C--\$3510. For constant exchange rate, the increase of 1400 shebangoes is equivalent to $(3500)(1400)/(4900) = x$ dollars = . So you would have to pay \$3510.

* * *

Question: Economists sometimes use what they call the "Equation of Exchange." This equation says that the supply of money (M) times the velocity of money (V) equals the general price level (P) times the real quantity of goods available (Q). The equation is therefore $MV=PQ$. Using that equation, what can

you tell me about the effect of an increase in the money supply (M) on the general price level (P)?

Answers:

Student A--P will increase. More dollars chasing same amount of goods. Simple cause and effect.

Student B--Having only brief contact with this equation before, I would say that increase in M would cause a reduction in P offset by an increase in Q and a decrease in V. Using present economic situation in reverse.

Student C--Increased money supply devaluates the dollar, therefore, the price level would increase. If the price level did not increase, there would be much more spending, but to tell you the truth, I think it could go either way.

* * *

Question: I know of a manufacturer who has found that no matter what price he charges, the quantity he sells always adjusts so that the total revenue is constant. That is, if he lowers his price, sales increase just enough to keep total revenue constant, and vice versa. He wants to know what quantity he should produce in order to maximize his profits. What would you tell him?

Answers:

Student A--He should produce to obtain a profit. He should lower his overhead.

Student B--He must pick his quantity so that the price is low enough so that the demand is high, but not so high that he cannot supply enough of the product to meet the demand.

Student C--It doesn't matter. Because if his total revenue is always the same, and his quantity sold, adjust to the price he is selling the goods for, keeping the total revenue a constant he could produce 1 or 1,000,000 units and never increase his total revenue.

* * *

Those three questions are significant to me because each requires thought processes which are important in economics and in many other areas of problem solving. In addition, they are problems which, in spite of the specific "content words" do not require prior economic education to arrive at a correct answer. Just as one does not need to be a physicist to isolate variables which might influence the flexibility of solid rods, so one does

not need to be an economist to utilize ratios to convert shebangoes to dollars. No economist has ever heard of a shebango anyway.

The first question implicitly asked the student to engage in proportional reasoning. The second demanded the capability of isolating a variable and analyzing its effect while mentally holding others constant. The third required the student to identify a relevant factor (cost) beyond those specified in the problem and to apply a proper algorithm to find a solution. While some students (whose answers are not reproduced here) answered each problem well, a substantial number demonstrated inability to deal with the requirements of the problems. Why? What can the economics educator do about it?

Generalizing from introspection, I presume that many of us would respond by saying, "Those students are dumb. They shouldn't be in college." And, finding them in our classrooms, we would recognize two alternatives. We could "flunk them out". Or, we could gear our teaching to their answers and hope that by teaching the algorithm for each type of problem, and giving them a basketful of "clues" about when a ratio is appropriate and when to say "all other things equal," etc., they could memorize their way to a passing grade. We would also recognize that after we had "taught" them to calculate dollar prices of Volksnotas, it would be up to the mathematician to "teach" them how to calculate the distance in kilometers from Wahoo to Broken Bow, given the distance in miles and the conversion ratio. That is, although the problems are formally identical, we are aware that they do not appear so to many students.

Bafflement at some of these student responses, together with dissatisfaction at the perceived options of dealing with them, evidently made me receptive to the possibilities in an alternative explanation and prescription. The alternative which has stimulated much of my recent educational thinking and activity is provided by Swiss psychologist and epistemologist Jean Piaget and his followers. While full explanations of Piaget's theories are available elsewhere (see bibliography) by people more competent to offer them, some brief recitation of my interpretation of Piaget's possible relevance to instruction in economics might better illuminate my view of the economic component of ADAPT.

The focus of Piaget's research and writing is the process of human intellectual development. The idea of "development", that is, progressive change, is crucial to understanding possibilities for learning. For Piaget, in each of four developmental stages through which a person passes from infancy to adulthood, certain kinds of mental capabilities are acquired. The developmental process is a process of acquisition of mental "structures" which allow performance of increasingly sophisticated mental tasks.

For one who has lived with and observed children growing up from birth through adolescence, the concept of mental stages of development is intuitively appealing. It seems clear that, regardless of the "intelligence" of a youngster, there are ages at which certain mental patterns or thought processes are not present. And it also seems clear that as the child grows older the complexity of mental tasks which can be performed increases. Piaget identifies the stages through which he believes we pass, suggests the kinds of mental processes associated with each stage, and cautions us that the rate of development is not uniform but varies between individuals and specifically between "cultures".

Piaget further hypothesizes that intellectual development is a function of four variables: maturation (and associated physiological changes), experience (both physical and mental), education (broadly defined), and "self-regulation". For him, self-regulation, the most significant variable, is the process whereby an individual mentally wrestles with discomfiting information (such as experimental results contrary to expectations) until a satisfactory mental reconstruction allowing intellectual equilibrium takes place.

To a college educator, the most significant aspect of the developmental schema is that which appears to be relevant to college-age people. The final two developmental stages discussed by Piaget are the stages of "concrete operations" and "formal operations". An "operation" is a mental process, the "essence of knowledge", in which the "object of knowledge" is acted upon. An operation may be ordering, or classifying, or hypothesizing. It is "concrete" (characteristic of the penultimate stage of development) if it operates on concrete objects or experiences. The operation is "formal" (characteristic of the highest stage in the Piagetian developmental schema) if it involves reasoning about hypotheses, mental manipulation of abstractions, reasoning about contrary-to-fact situations, and operations of propositional logic. (These are not meant to be exhaustive or scientifically precise definitions.)

Obviously, against the background of the Piagetian theory, many persons with college classroom teaching experience may be tempted to wonder whether there is not a possible mismatch between the level at which the student is prepared to receive learning and the level at which instruction is offered. Piaget (1964, p. 180) specifically notes that

"(the student) can receive valuable information via language or via education...only if he is in a state where he can understand this information. That is, to receive the information he must have a structure which enables him to assimilate this information. This is why

you cannot teach higher mathematics to a five-year-old. He does not yet have the structures which enable him to understand."

My colleagues in ADAFT and I have succumbed to that temptation to wonder about consistency between levels of teaching and structures for learning and have begun to consider the consequences of teaching a subject (such as economics) using texts, problems, examples, and language which demand mental skills typical of a "formal operational" learner. If, as Piaget seems to believe, all persons attain the formal operational level during adolescence, or certainly by age 20, disparity between level of teaching and preparation for learning should not be a problem. If, however, we are aware of the several studies¹ which indicate that many of the skills identified with formal operations (combinatorial logic, proportional reasoning, separation of variables) are not evidenced by a large proportion of college students, we must consider our options.

If we are willing to consider the possibility of developmental stages, roughly as described by Piaget, and if we agree that many of our college students do not seem to function at the formal level, at least in some disciplines, two choices are apparent. We can ignore the theory and the data and continue to teach, presumably at the formal level, with continued mixed results, occasionally resembling those with which this essay began. Probably the less clever "concrete" thinkers will soon "flunk out" and quit giving us disquieting answers to exam questions. (Or, if we make those questions multiple-choice, we won't see the mental process at all.) The more clever or diligent concrete thinkers may struggle to a diploma via memorization or algorithmic applications.

Or, we can attempt to revise our pedagogy to make it accessible to the concrete as well as the formal student. How that might be done, or at least attempted, is the stuff of most of the rest of this essay. It is that attempt that consumes the time and energy of the ADAFT staff.

Before discussing concrete curricular or pedagogical adjustments which have resulted from the Piagetian perspective, one other aspect of the developmental theory should be re-emphasized. That is the speculation that experience and self-regulation are two of the agents which foster progress from one stage to the next.

¹Among them: Jackson, (1965); Karplus, (1974); Lawson and Renner, (1974); Lovell, (1961); McKinnon, (1971); Renner and Lawson, (1973); Tomlinson-Keasey, (1972); Towler and Wheatley, (1971); Wason, (1968).

The idea of reconstructing higher education to make it accessible to pre-formal thinkers is attractive to me only as a development-stimulating process. If we can provide environment and experience necessary for self-regulation to occur, and hence to assist the transition from concrete to formal, the potential worth of such pedagogical modification is immense. If no development is fostered, or if the group of students we are trying to advance are not capable of making the transition, the benefit-cost ratio would not be appealing to me.

At this point we should become much more concrete and discuss the teaching of economics from a Piagetian perspective. We should first turn our attention to consideration of how a number of basic economic concepts, taught in almost every "principles of economics" course, fit within the the Piagetian classification. My thoughts on this are preliminary and tentative.

As I understand Piaget, concepts which are concrete or accessible to the person in the concrete operational stage of development are likely to possess some of the following characteristics:

- 1) drawn directly from personal experience;
- 2) involve elementary classification and generalization concerning tangible objects;
- 3) utilize direct cause and effect relationships in a simple two-variable situation;
- 4) can be taught or understood by analogy, or algorithms, or "recipe;"
- 5) are "closed," not demanding exploration of possibilities outside the stated data.

Conversely, concepts which are formal or accessible to the person in the formal operational stage of development are likely to possess some of the characteristics in the following list:

- 1) may be hypothetical, imagined, contrary-to-fact;
- 2) may be "open-ended" demanding speculation about possibilities not spelled out;
- 3) may require deductive reasoning from unverified hypotheses;
- 4) may require definition by means of other concepts of abstractions, with no obvious correlation to tangible reality;
- 5) may require intermediate steps or concepts not established in original data.

If we look at the content of early courses in economics, how do the things we teach fit within the classification system described here? A list of topics often covered might include,

among many others, gross national product, demand, comparative costs, economic profit, multiplier, equilibrium, investment, economic efficiency, elasticity, marginalism, income tax, index numbers, and returns to scale.

Some of these ideas, such as income tax, investment, gross national product, seem amenable to definition and explanation in terms of familiar situations or examples and are probably properly thought of as within the concrete realm. (Some aspects of these, such as imputed income in GNP calculations, may be more difficult for the concrete operational person to comprehend.) On the other hand, comparative costs, multiplier, economic efficiency, and economic profit must be defined in terms of other concepts and/or functional relationships, or make use of proportional reasoning or idealized models, and may properly be classed as formal concepts. (Now I understand why so many students have so much trouble understanding those "Florida oranges"/"Nebraska wheat" comparative cost tables designed to illustrate potential gains from trade. They require a kind of proportional reasoning which may be out of reach for some students.) Concepts such as marginalism, or elasticity, are, I think, formal; but they can rather easily be explained quantitatively with simple formulae and algorithmic thinking. This last point is important because it suggests that formal ideas may be discussed concretely; it is equally likely that concrete ideas (such as demand) can be discussed quite formally.

Obviously, one conclusion which emerges from all of the preceding hypothesizing is that the topics we teach, or the way in which we teach them, may be inaccessible to learning by some of our students who have not yet achieved the formal operational stage in the development process. Whether their developmental process might be stimulated by a pedagogy which utilized their concrete operational skills, provided added experiences as raw material for mental growth, and encouraged self-regulation to take place is the question addressed by the ADAPT program.

The translation of Piagetian theorizing into a college economics curriculum by a person with no claim to competence in developmental psychology is a frustrating, time-consuming, difficult process. What follows is a discussion of premises from which I began, objectives by which I was guided, and pedagogical methods used in an attempt to create Piaget-based economic topics course for college freshmen. The process continues.

The premises on which the ADAPT economics curriculum is based are drawn from Piaget's work. They are, basically:

- 1) there is a process of human intellectual development;
- 2) a significant proportion of college freshmen are not yet "formal operational";

- 3) utilizing an educational strategy which makes concepts accessible to the concrete operational student, and which causes intellectual "disequilibrium," may lead to "self-regulation" and intellectual development.

As I work from those premises to construct and implement an economics curriculum, my objectives include the following:

- 1) to build a "learning cycle" (exploration, invention, application, as described below) for each unit of instruction;
- 2) to ensure, as part of that learning cycle, that each unit has an "experiential", "concrete", exploration activity which allows students to generate data and actively participate in an economic activity;
- 3) to establish circumstances where mental "disequilibrium" is likely to occur and where "self-regulation" could follow.

In my view, and as reflected in Piaget's experimental work a laboratory or similar opportunity for "doing" the exploratory work is a key element in the pedagogy. Such an involvement with the subject matter is vastly preferable to simply thinking about it or listening to someone talk about it. Of course, in this respect, natural sciences seem to have a pedagogical advantage over the social sciences; and the latter a similar advantage over disciplines such as English or philosophy.

Although economics is not usually taught as a laboratory subject, and, in fact, an economics laboratory is not easily developed, two kinds of activities have been useful to me in this Piagetian venture. The first, employed whenever possible, is direct, "real world" activity. This can be employed with topics such as price indices or public finance. The second kind of activity, resorted to when real world interaction is not feasible, is in-class simulation games and activities. This is suitable for macroeconomic theory, or money expansion, or international trade. Some topics, such as market structure, can be developed via a combination of gaming (to illustrate oligopolistic market behavior) and community activity (comparing prices in competitive versus oligopolistic markets).

One example from each pedagogical mode ("real world" and simulation) may indicate how I view the implementation of a learning cycle approach to economic activities.

Development of a College Student Price Index (analogous to the Consumer Price Index) is one "real world" activity which ADAPT students have accomplished and which exemplifies most of the pedagogical components discussed so far. Particularly during an

inflationary period, a device which can help them see the shape and size of inflation as it affects them, is of interest to students.

The exploration phase of this learning cycle involved two components. One was a survey of the students themselves to determine what they bought and what they spent for it. The basis for the survey responses was a record the students were asked to keep for a period of two weeks, listing all purchases and amounts expended. The second exploration component was gathering price data from the shelves of Lincoln merchants.

Many "inventions" of kinds of concept formation were necessary to bring construction of a respectable price index to completion. One invention centered on the concept of a "representative market basket" of student utilized commodities. It was of course apparent to the students that we could not manage an index which contained every conceivable purchase during the school year. Thus their own records of purchases made were used to generate a list of 65 products, selected by the class, to represent their buying activity.

The students were soon confronted by the fact that simply adding up the prices of the selected commodities during two time periods and comparing the results was not sufficient as a representation of changes in their purchasing power. The importance of each item, or class of item, in their budget needed to be considered; thus the ideas of grouping the commodities into "classifications" and appropriately "weighting" each class were interjected. Six classifications were used (food, toiletries, school supplies, recreation, clothing and miscellaneous) and weights were assigned again based on recorded expenditures over the two week period. (Housing was omitted because of the anticipated stability of dorm rates during the academic year.)

The necessity for developing standards and specificity in product selection quickly became apparent. Simply going to the store and pricing "soap", or "gasoline" was not good enough; and our list soon specified "Dial, 5 oz.", and "DX plus" gasoline. Thus the idea of "care and rigor in data collection", and the possibility of subsequent "replication", were made tangible to the student.

Not to be forgotten among all the other inventions which were occurring is the concept of an "index number" itself. The students found indexation a useful concept to make some sense out of the mass of information gathered over a period of time; and it was regarded as a helpful aid rather than a teacher-imposed harassment by the time it was used in class.

Finally, the application phase of this unit is nicely built in, as the students were given the job of price gathering and index calculating at the first of each month. Thus we watched the index grow from 100 on September 1 to the level of 104.8 on March 1. Each month the movement of the components of the index is somewhat different, the effects of seasonal changes are apparent, and the students become more comfortable with this tool. Disequilibrium and self-regulation were a natural and unavoidable part of the process. Having student A price soap one month at \$.89 and having student B report it at \$.35 the following month led to the self-regulation of product specification and standardization. The idea of grouping and weighting grew from the disequilibrium caused by having the 10% change in the price of a pair of shoes completely overwhelm price decreases in small-ticket items such as toothpaste when the entire list was aggregated in an undifferentiated way.

Simulation activities, although more artificial than price index construction, appear generally engrossing to students and have been used frequently. One successful venture involved several simple trading activities carried on in the classroom and designed to teach something about relative prices, market equilibrium, and gains from trade.

Our trading activity began by grouping students into clusters of eight (each of which could be regarded as a country), and allocating a set of commodities (jelly beans, gum, pencils, paper, paper clips) to each student. Allocations varied among students, and among groups, although some of the groups received allocations heavily weighted toward the edibles, and the rest received allocations heavily weighted toward the office supplies.

Intra-group trade then took place, with students recording the offer and trade process, until "equilibrium" was reached. We discussed why trade occurred, who "gained" from each trade, and why trade ceased.

Each group was then asked to develop group supply and demand curves for one commodity in terms of a second (gum in terms of jelly beans). They tested both supply and demand at various hypothetical prices, aggregated the data across the group, and graphed it. This exercise also established an equilibrium price for the commodity in question within each group.

Finally, the groups were free to engage in inter-group trade, again recording the process carefully. As expected, trade flowed from low cost to high cost countries, with all costs being denominated in goods. Thus the students could easily see that different gum:jelly bean prices in two countries established potential for gains to both via trade.

In this trading exercise the exploration activities involved the trading itself. Inventions included utility, demand and supply curves, relative prices, and gains from trade. Applications of these inventions were, unfortunately, primarily paper and pencil replication and problem-solving.

I would not claim any novelty in the use of classroom games or simulation activities. Such devices are familiar to many innovative educators and readers of pedagogically-oriented journals. What I do claim as novel is the establishment of a connection between all such "concrete" activities and a psychologically based theory which illumines the role such activities can play and the objectives they may fulfill. Thus instead of haphazard use for reasons of novelty or student enjoyment, they become the necessary exploration and disequilibrium components of the concrete/formal transformation process.

Other concepts in economics can be approached via the learning cycle. Doing so generates greater student involvement with their own learning, allows them to work with data of their own development, and assures that the valued concepts emerge from concrete activities familiar to the students.

After one year of "ADAPTATION" in economics, what sort of appraisal is warranted? A cautious one. Quantitative information is not yet available on student mental development, personal growth, college dropout rate, etc. I believe I can identify pedagogical improvements yet to be made, such as further individualization of materials to accommodate better the wide range of student capacities and interest. I know that we dealt with fewer economic concepts during this academic year than I would have "covered" in a standard principles of economics course (perhaps this year we "uncovered" a few.) And yet I've worked much harder.

My professional assessment at the present time would include the following observations.

A. The Piagetian framework for understanding human intellectual development is useful in explaining the kinds of learning problems which appear in my classrooms. I am reasonably sure that a significant portion of my students cannot engage in "formal operations".

B. That understanding forces me to face that problem. I know that some of what I teach in economics is properly regarded as demanding formal thought. My past teaching habits involved extensive presentation of abstract concepts beyond the reach of "concrete operational" students. I can choose to revise my teaching to increase the accessibility of the material or I can

"flunk out" the less advanced students.

C. The prospects of enhancing intellectual development through pedagogical activities which focus on that objective are stimulating enough to cause me to continue the attempt to develop techniques and materials suitable for that task. Until we demonstrate that such intervention is ineffectual, or is more costly in terms of effort, content mastery, or some other relevant variable, than the benefits merit, my involvement with this line of exploration will continue.

Occasionally I slip back into the comfortable lecture mode, and "tell the students what they need to know". They are respectful and attentive (probably relieved to sit quietly back in blissful inactivity for a change) and it "feels good" for me to be doing what I'm comfortable with. The lectures I deliver are generally good, clear, articulate, precise, sprinkled with humor, and well-paced. I leave the room on such occasions feeling very pleased with my hour's effort. But, when I try in a subsequent class period to retrieve from the students what was delivered to them two days previously, my "high" evaporates. There is little retrieval possible.

The results from the "learning cycle" are better--not perfect, but better. Students who have been involved with the materials and have generated the data seem to have a stronger, surer grasp of what concepts are involved. The ideas mean something to them, in terms they can understand, and therefore are better retained and used. And it's exciting, even for an instructor, to watch textbook concepts actively reproduced in a classroom setting.

On balance, I've seen enough to continue the activity. Perhaps, as an additional year or two of curriculum development and experience passes, strong positive results will be apparent. Perhaps not. But the pursuit of student intellectual development and the potential implications of Piagetian theory for college teaching make the venture worth the effort.

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CHAPTER FIVE

Piaget and Mathematics Students

M.C. Thornton

Usually in the beginning courses I teach there are several students who never seem to understand what is really going on. These students are neither lazy nor dumb. Some even work very hard in math and do quite well in their other courses. Yet, there seems to be something about their work in mathematics which produces frustration instead of understanding. I recall experiencing that kind of "learning" in high school geometry. I and many of my friends got fairly good grades in that course by memorizing without such understanding. As a high school sophomore I was just not ready for deductive reasoning, proofs, axioms, etc. There were some essential mental skills which I had not yet developed.

As all college teachers know, the lack of certain specific mental skills is not restricted to high school students. Recent research can document that fact quite well, (Kohlberg and Gilligan, 1971; Lawson and Renner, 1974). To be more specific about mathematics consider the following examples of reasoning from freshmen.

Problem: Suppose the two triangles shown are similar. Find the length of s .



Solution: $s = 2, 7, 4, x, 3$. Since $2:4:3$ then $s:7:x$ or $5:7:6$.
So $s = 5$.

Problem: Your instructor is 40. You are 18. In percent, how much younger than the instructor are you?

Solution 1: $18/40 = 0.45 \times 100 = 45\%$ younger.

Solution 2: $40/100 \times 18/x = 720/100 = 7.2$ percent.

Problem: A rat going through a certain maze must make four decisions whether to turn left or right. One path he could take may be described as LLRR, which means turn right, turn right, turn left, and finally turn left. List all possible paths the rat might take.

Solution: LLLL LLRR LRLR LLLR LRRL LRRR

FELL RLRL RRLR RLLR RLLL RRRR

Theorem: If a series converges then the n-th term must tend to zero as n goes to infinity.

Student application: Since $\lim 1/n = 0$, the harmonic series $1/n$ converges.

What is striking about these examples is how accurately they are described in terms of Piaget's concrete operational and formal operational stages. Proportional reasoning, ability to conceive all possibilities, and use of basic propositional logic are three factors which distinguish the concrete and formal stages of development (Inhelder and Piaget, 1958, chapter 17).

Borrowing heavily from J.D. Berron (1975), L. Copes (1975) has given a list of tasks commonly expected in basic mathematics courses which he suspects most students not at the formal operations stage cannot do with understanding. Here is Copes' list.

Concrete-operational students

can

make routine measurements and observations

answer acceptably the question, "Are there more squares or rectangles in the diagram?" if they realize that all squares are rectangles

But can't

measure "indirectly" quantities such as speed and acceleration, perhaps even area and volume

respond correctly to the choice, "If all squares are rectangles, then: 1. all rectangles are squares; 2. some rectangles are squares; 3. no rectangles are squares."

order a collection of sticks according to length

count and perform elementary arithmetic operations

manipulate algebraic expressions including fractions

generalize simply from given data: all quadratic equations (in x) represent parabolas

decide who is tallest if told that Bill is taller than Tanny and shorter than Sheila

systematize counting procedures well enough to understand permutations and combinations

given the equation $y = 3x^2$ or $y = 1/x$, decide what happens to y as x increases

perform a "once-removed" generalization: Since quadratic equations in x represent parabolas, so do quadratic equations in y .

From recent experience with freshmen, I would add that most concrete-operational students also

Can

solve $x/3 = 7/5$ for x

change a number from base ten into base two using a memorized procedure

write numbers in scientific notation

apply memorized formulas to find the mean and standard deviation

find the intersection of two given finite sets

list all possible outcomes of flipping two coins

work through a flowchart with a given set of data

write simple truth tables involving implication

compute what percent 6 is of 8

But can't

find the shadow of a three foot child when his five foot mother has a seven foot shadow

use the analogous process to write numbers in base three

solve linear equations with coefficients written in scientific notation

decide whether the computed mean and standard are at all reasonable for the data

draw a Venn diagram to represent "some A are also B"

easily list the outcomes for three and certainly not for four coins

discover that the flowchart just counts the positive data points

give a specific example of the denied antecedent fallacy

find the percent change from 8 to 6

Copes summarizes concrete operational students this way: "If I am at all correct, it follows that they are not able to follow a formal argument, much less to come up with a proof of their own. They cannot grasp the concept of a function, because the concept of variable is not clear. And, in terms of attitude toward our field of study, they certainly cannot appreciate playing mathematics, seen as a rule-oriented game. ... It should be clear by now that the students we are discussing are not stupid or lazy. Perhaps they are not "reasoning" in our logical sense of the term, but we need to consider the possibility that this is due to gaps in the development of their mental structures rather than to inherent lack of growth potential."

Piaget's theory of intellectual development provides not only a very compelling model for the description of reasoning skills but also a possible prescription for student growth. In his article Piaget (1974) comments, "My first conclusion is that learning of structures seems to obey the same laws as the natural development of these structures. In other words, learning is subordinated to development and not vice-versa."

The doctor's orders seem to be: If the symptoms of the mathematics student are those of concrete operations, we cannot treat him by working on the symptoms, that is by teaching specific facts, concepts, methods. The cause must be treated. We must somehow change his level of development before satisfactory learning of certain mathematics content will be possible.

This prescription seems very difficult to take. It is much easier to restrict attention to mathematical concepts from a course syllabus than to be concerned about a student's entire intellectual capability. Discovering how a student reasons about a problem takes much more time than asking if he has a correct answer. Time spent on reasoning processes will restrict, sometimes severely, the amount of time available for mathematical content. An additional complication is that usually a student's mathematics class is just a small part of his academic load. Can one reasonably hope that what is done in one class will necessarily transfer to other courses and to his life outside the university?

Of course one cannot teach a mathematics course and expect to affect reasoning skills or anything else without including something to reason about. The ADAPT mathematics class was designed to contain mathematics which would encourage the students to consider their own reasoning and which would be useful in their other courses that semester. Content for the class was also chosen to be new and interesting to the freshman with a one to four year preparation in high school mathematics. The emphasis was not on formulas and correct answers but on the reasoning behind some formulas and how they could be applied.

The class usually met for three fifty minute periods each week for both the fall and spring semesters. Several times during the first semester classes were held jointly with physics, and these lasted two to three hours. The first part of the fall semester was to be a review of many mathematical ideas from high school. This material turned out to be new to many and thoroughly forgotten by most. Topics included functions with domain and range, inductive thinking, deductive thinking, similar triangles, percentage, number-numeral distinction, scientific notation, and a great deal of practice on linear equations, both graphing them and finding the equation from the graph. The work on scientific notation and linear equations covered a three week period when the same topics were considered in physics.

The middle of the semester began with work on logarithms. They were introduced using base 2; properties of logs were discovered and then extended to base ten. Both four place tables and pocket calculators were used for computation. A little over a week was spent on base two numeration, the binary sequence and its application to counting problems. Box puzzles were used to review arithmetical operations with fractions and decimals and to find the sum of an arithmetic series.

By this time the students had gathered lots of data in their anthropology course and had begun to see the need for statistical treatment. In mathematics they spent two weeks considering the notions of frequency distribution, mean, median, mode, and standard deviation. These ideas were then applied in their physics lab in predicting the pattern of falling pellets.

The last three weeks of the first semester were used to study unions, intersections, complements, deMorgan's laws, Venn diagrams and their use in organizing the displaying data for solving problems. Each student used a set of cardboard objects of various sizes, shapes, and colors to make their work in set theory more concrete. Some work was done in trying to draw Venn diagrams which represented logical connections expressed in English sentences.

Beginning logic was treated the first four weeks of the second semester. The operations from set theory were translated into logical connectives. Truth tables were done with three independent propositions. Implication and the logical fallacies of the denied antecedent and the affirmed consequent were discussed. Almost a quarter of the students were interpreting p implies q as p is equivalent to q . This was expected in the light of O'Brien's findings (1973) on the use of implication by college students. Some work was done on syllogisms using Venn diagrams. All but a very few found syllogisms quite difficult.

The next four weeks treated significant figures and exponential functions. At this time in physics they were taking a lot of data related to exponential growth and decay. Mathematical problems were worked based on measured data to show that even though their calculator gives an answer with ten digits, only the first so many are significant. Semi-log graph paper was used in graphing exponential functions. Material on logarithms and linear functions from the first semester was recalled to determine the exponential function from a straight line on semi-log paper. The experience on exponential functions was applied to compound interest problems.

The students spent three weeks working with flowcharts. Almost all were eventually comfortable following a given flowchart to make specific computations or decisions. Some students fairly easily constructed flowcharts for given processes or algorithms. Many students had trouble making flowcharts because the reasoning processes used to solve certain problems were not clear enough for them to write down in a flowchart format.

The last portion of the semester dealt with the idea of a mathematical model. Ideas and procedures from other courses as well as those in mathematics were interpreted as models. Models were constructed and applied to decision and prediction problems using the methods of least squares, linear programming, and critical path analysis.

It was very rewarding to see examples of how the content from this course was used in the students reasoning, especially when used outside the class. The most obvious examples of such transfer were in the statistical methods used in anthropology and in the applications of linear equations, exponential functions, graphing and computational skills used in physics. There were other less expected occasions. During the seminar when the students were given the results of the personality inventory they had taken, some discussion was not in terms of "Am I above or below average?", but rather, "Am I within a standard deviation of the mean?" in giving an explanation of the relationship between two attributes of human behavior in an anthropology journal, one student did it using a Venn diagram. In a history examination question one student responded by specifically mentioning the logical form of the argument. During an economics class a student was reporting on estimation of tax revenues based on percentage increases from previous years. Another student commented, "Hey, that makes it an exponential function."

How can I best get my students to understand this concept? The instructor who views his students with Piaget's model of intellectual development can ask that question in a sharper form: How can I plan a basis of concrete activities and disequilibrating

experiences so my students will develop adequate mental structures for this concept? In either form, the question is a hard one. You soon discover that what seems very concrete to you may not be concrete at all to your students. So the second question may be no easier to answer than the first. But with each way of asking the basic question, with each way of viewing how students can learn, we gain an advantage for some students. Piaget's theory is effective for a great many students. Using it can help maximize the number of students who will say, "Hey, that looks like an exponential function."

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CHAPTER SIX

ADAPT HISTORY:

The Inexpensive Unification of Clío and Piaget

by L.C. Duly

Recent experimentation in the teaching of history at both the secondary and tertiary levels displays a wide variety of approaches designed to preserve the integrity of the discipline while overcoming the seemingly increasing ahistorical orientation of students. Although it would appear that experimentation at the secondary level has been more vigorous and more creative, the inclusion of history per se within broader definitions of a social science curriculum has made many of these programs somewhat inappropriate for use at the college level. Critics of high school experimentation have criticized--perhaps unfairly--the new approaches for failing to give students a sense of the historical perspective: an understanding of man through the concept of time and in-depth relationships. Experimentation at the college level has taken a variety of forms: the "repackaging" of older courses into more social and culture-oriented courses (the contents of which are supposed to be of more interest to the students of today); the development of new multimedia courses, designed to heighten the student's perceptions; the creation of courses stressing thematic processes within aspects of history; or the supervision of small-group investigative programs. The techniques at the college level have ranged from a revitalization of the lecture and discussion format to the formation of one-to-one student/teacher ratios in personalized experiences. Within the profession at the college level, debate is increasing as to what devices or methods serve both the instructors and students best. A certain reluctance is evident on the part of the profession to venture too far into new teaching methodology unless assurances can be given that the costs are within reason, that the approaches have a universality not confined to one professor or institution, and that the benefits will include a preservation of the discipline's standards. It is perhaps too early for many of the current projects to demonstrate their performance in these three areas.

The ADAPT History course at the University of Nebraska-Lincoln is still very much in its infancy. To date it has consisted of a two-semester course dealing with the nature of "revolution and other forms of change" in Modern Europe from 1776 to the present. The thematic tone of its title has been kept deliberately vague; its content has tended to stress the origin, development, and change of ideas, institutions, and value-structures within the established chronology, all of which one would likely find in the traditional "Western Civilization" course. The course has not attempted to present the study of man in some new mode or to create a multimedia framework. It has benefited from being a part of the ADAPT project in that students have had opportunities to bring into the course discoveries and experiences gained in their other academic work. However, the instruments of the course have been only those of one instructor and a typical selection of about 30 freshmen students¹ one would find in any other history course at the University. Yet, because of the utilization of Piagetian learning concepts, the course is a marked departure from existing courses in the Department's program. An index of its worth at this point would lead one to suggest that it may meet the criteria expected by the profession: a limited investment of time and money, a relatively easy application of its format to other history courses and to other groupings of university students, and the maintenance of the discipline's commitment to scholarship. Since Piaget has already found its place within the learning programs of many high school and primary school curricula, the ADAPT course may also provide a vehicle of communication so necessary among teachers of history at all levels in the American educational structure.

The essence of the ADAPT course is its emphasis on recognizing and working with the various levels of cognitive development of its students. Its first requirement has been that of learning where students are in the perception of problems, their applications of "solutions" to these problems, and their ability to comprehend and weigh variables. As pointed out in the introductory essays to this volume, the Piagetian concept of learning sees the need for students to use self-regulation as the process by which they can go from the Concrete stage of reasoning to the college-expected Formal state. If we face any new problem by calling upon our past experiences for solutions, then we can readily see what Piaget states as the basis of the process of cognitive expansion. Unfortunately, our assumption in history calls for students as well as ourselves to be at the Formal level of analysis: to be able to comprehend and use abstractions, to recognize contradictions as well as similarities, and to use one mental image to explain

¹Enrollment was 32 students first semester and 28 students second semester.

another. Learning situations which do not give students an opportunity to participate in their own internal self-regulation--that is, learning situations which begin at the Formal state--are unlikely to be of benefit to students who have yet to reach the same stage of mental analysis as that of the instructor.

Since the historian's task is that of making rational the irrational, of using the scientific method to handle the subjective, it is not easy for him or for his students to be "measured" by the tools designed for other disciplines with more pronounced or obvious thought patterns. Typically, we measure our students within the demands of the discipline: we evaluate their answers to our questions. In determining where students are as they enter the ADAPT History course and as a continuing device to "test" cognitive development, I have reversed the typical process: I solicit their questions in a variety of ways. The most important may be in the form of the first examination, given much earlier in the course than one would normally expect. Students are asked to put themselves into the role of the instructor and to frame the questions that they wish to answer on the examination. Each student is asked to bring to the examination period (written on the first page of his "Bluebook") three essay-type questions over the unit covered by the class. Questions are then discussed by the class at the beginning of the period, and then the class is either assigned a "composite" question or the students are told to select their "best" question and write a model answer for it. By asking for three questions, the exercise usually forces students to go beyond those which the instructor may have posed. Although a range of thinking might be evident in a student's list of questions, it is fairly easy to "classify" the student's level of thinking. Since students also read another student's essay as well as their own work, the instructor is given additional insight as to the particular skills, needs, and value-structure of each student within the context of the course. Using the Piaget classifications, students in ADAPT as well as in my other classes where I have used this approach this year may be classified as follows:

Concrete thinker--sees only limited, immediate relationships; single causation; and little awareness of inter-relationships.

Transitional thinker--begins to see more general relationships among a series of "events" and shows some skill in separating as well as uniting variables and determinants.

Formal thinker--unites generalizations to formulate observations and insights about man in society; unites periods of time; sees the interplay of ideas and action; cautious in assuming that one can see casual relationships among "isolated facts."

That a high proportion of freshmen students today cannot do well in history courses in which content is presented at the Formal level is suggested in the following table, recording the placement of all freshmen students I have had in all of my undergraduate courses this year. In each instance the classification was devised through self-generated question-type examinations as described above. Although the contents of this table must be considered the results of a crude and limited measurement, I found in working with the students that about only one or two out of every five began the semesters' work at the Formal stage of analysis.

	<u>No. of Students</u>	<u>Percentage of Students*</u>
Pre-Concrete**	11	11.
Concrete	51	50.
Transitional	17	17.
Formal	<u>22</u>	<u>22.</u>
Totals	101	100.

*In rough percentages only.

**Many Pre-Concrete students, characterized by either an inability to express a recognizable form of logic or a willingness to participate in the classes, could not be adequately "measured."

With the sobering insight that many students were hurt by the lack of cognitive skills as opposed to a lack of interest in history, I became especially concerned about introducing each unit in the ADAPT course in the form of "Concrete" experiences. In its daily format as well as in its semester-long objectives, ADAPT History, in conjunction with the other ADAPT courses, used Piaget in a three-part learning experience.

In the first part, Exploration, subjects were introduced in familiar and limited forms. Questions by both the instructor and students focused upon a specific problem or observation, or the classroom material used uncomplicated and controlled variables. For example, to move to an eventual understanding of the diplomatic alliances among the major European states from 1890 to 1914, the first part of the unit emphasized personal perceptions of power ratios through the playing of the simulation game, "Shipwreck," developed by Abraham Caplow. The game calls for three players, each with a different "power ratio," to negotiate strategies to

protect their own interests. Subsequent questioning of the students concerning the decisions they made brought out in very explicit terms the vocabulary and the logic they used to "survive" in the game. In the second part of the learning cycle, called Invention, students were placed in a "state of disequilibrium"--a situation in which they found that while many of their concepts or solutions from "Shipwreck" might fit a new set of problems, they still had to invent new strategies or concepts in order to cope with the problems. Giving each European state a power ratio comparable to those assigned to participants in "Shipwreck" and then asking students to determine what combinations of states made the "best" alliances was the opening exercise for the study of the European alliance system in the Invention phase. Students quickly found that the "formulas" they had invented earlier could not be used to cover their increasing exposure to the variables in the patterns of European diplomacy, yet the relationship between their experience in the game and the realities of the alliance system suggested that the two situations were not totally dissimilar. In this phase, students found it necessary not only to change some of their assumptions but also to seek out additional information from inclass sources and supportive outside readings. Here, students were learning what they did not "know" yet were developing formulas for finding out what they needed to learn.

In the third part of the learning cycle, Discovery, students are supposed to have completed the process of self-regulation--to gain equilibrium once more--and to be in a position of seeing variables and possibilities not apparent in the Exploration stage. For the learning cycle on diplomacy, students were able to discuss as well as to suggest the contradictions within the alliance systems, to probe indirect as well as direct relationships, and, most importantly, to ask and to synthesize questions that showed they had placed their own exploration, invention, and discovery experiences within the larger framework of the study of history.

It may be asked if Piaget is suitable for only the college student who is at the Concrete stage in the study of history. Since there was no attempt throughout the course to separate students, Formal thinkers did participate in all of the phases of the learning cycle. It appears that they did push faster into the Invention phase. Yet this was not a consistent pattern--some found they could handle certain situations quickly one day, whereas in facing a different dimension of history at another time, they, too, seemed to gain from the familiarity and security inherent in the Exploration phase. They also served as classroom leaders and fellow teachers--roles which I believe helped them to expand their abilities further.

Although few lectures were given, and then only in the Discovery stage of a learning cycle, I did not feel that I was

having to "water-down" the discipline. Fewer topics may have been included in the course's content; however, the utilization of primary sources and different historiographical approaches within the learning cycle allowed students to become more deeply involved in identifying and using historical judgments than is typical with undergraduates. These skills were self-acquired rather than "imposed." The flexibility in the internal format of the course allowed me to respond to the specific needs of the student as well as to the progress of the class as a whole. In short, we could "slow down" or move more quickly depending upon how difficult students found the stages of Invention and Discovery. Those unable to "complete" a stage could be given an immediate encouragement or additional experience not usually possible in courses of comparable size.

The longterm impact of the course and the ADAPT program on the students will have to be determined at a later date. One cannot claim that this course, or any of those in ADAPT, made Formal thinkers out of Concrete students. However, perhaps the process was started. The enthusiasm of the students in the history course plus the amount of work they were willing to undertake indicated to me that the experience was worthwhile, if not rewarding, both to them and to me. The size of the class seemed not to influence what we did or could do in using Piaget. (This suggests that a class of 50 or 60 students might pose some problems not encountered in this year's class of 30, but at this point there seems to be no fixed limitation on class enrollment for an ADAPT-based history course.)²

If Piaget has a particular significance for the teacher of history at the university level, it is that it transfers to the student responsibility for learning. It decreases passivity. And it allows even first semester students to discover that the pleasures of the discipline can be shared by them.

²Obviously, a class of 100 or 200 students would be excessive for any one instructor, but such large classes--one might argue--jeopardize any effective, active learning process.

CHAPTER SEVEN

A Place for Philosophy in the ADAPT Program

by E.T. Carpenter

Although there are many ways in which the ADAPT program is importantly different from other educational programs in the United States at this mid-seventies time, surely it stands as impressive in higher education by being the only college program spanning six disciplines which seeks primarily to employ the genetic epistemology of Jean Piaget in diagnostic and teaching strategies. It stands as a testing ground for a revolutionary hypothesis about college-level education: the degree of effectiveness of a teaching strategy depends directly upon the logical ability of the individual learner and his place on the developmental continuum relative to the logical demands presupposed by the assignment.

Back in 1935, Piaget remarked that "there are two terms in the relation constituted by education: on the one hand the growing individual; on the other the social, intellectual, and moral values into which the educator is charged with initiating that individual." He suggested that adults, being the "teachers" for the most part, seeing things from their own viewpoint and being ignorant not only of the state of the "learner" but also of the sorts of changes that the learner must undergo to gain understanding of the adult's knowledge, engaged in perfecting methods of teaching which made the role of the student primarily one of passive receptor while the teacher was active in "transmitting," in "passing on," usually verbally, the values of his society.

This state of affairs has been, in small measure, broken down in some sectors with respect to elementary schools. But the forty years since Piaget made these remarks have not seriously seen much of a change on the college and university level. When college teachers think of themselves as "teachers," even in the 1970s, the prevailing image they have is of themselves lecturing while the students are listening. The passive-receptor role of the learner is still widely assumed by American college teachers. All the while large proportions of entering college freshmen do not finish their year in college and more do not return for a sophomore year. Also we notice too often that those who do stay in may complete one

semester's course with adequate grades and then go on to the next level of course work improperly prepared by the courses that were prerequisite. Obviously, is something seriously wrong in the higher level institutional teaching-learning situations--something that heed of Piaget's definition of "to educate" from 1935 might have served to allay. Yet the adult in Piaget's definition of the "relation" has apparently behaved egocentrically ignoring, as do young children, the possibility of viable positions other than his own.

With the inception of the ADAPT program there is the occasion for testing-out of certain parts of the Piagetian theory of development as related to the teaching of young adults -- 17 year olds and older -- within the college setting and involving integration of several disciplines. It allows us to see if attention to the logical development of the student in planning the activities by which he is to learn does make a difference in the quality of his understanding. It provides the occasion to find out whether within specific disciplines there are characteristic developmental steps in knowing -- such that ordinal scales within some new contexts may be suggested. Further, it supplies an opportunity for competent people in different disciplines to come to understand better each others' fields and intellectual concerns, to respect and to cooperate with them in fostering their students' learning.

Since diagnosing the ability of the student by means of looking at the forms of reasoning he exhibits in the course of problem solving involves one in a sort of elementary formal logical analysis which philosophers have long counted among their professional skills, it would seem natural that the ADAPT program have room for philosophy at least in so far as it is hoped that the students in the program be made aware of their own reasoning patterns preparatory to consciously controlling their use. It would have been exciting for the program to have included philosophy as one of its six disciplines, but since that had not been so; it was suggested that some of those ends which a philosophy course would have served might be met by a seventh "course" in the program.

So, for one hour weekly, ADAPT students attended a seminar in which they are asked to reflect upon the things they were doing in their six courses and upon their relationships to those things. The aim of the seminar was not to provide them with specific ideas, tools, or skills; rather it was intended to give them at least one period each week where they would have intellectual space and time to "get it all together"--their ideas, their ways of working, their feelings, etc. In the seminar they were encouraged to formulate their views of their "world" in college and to focus on similarities and differences in their reasonings and valuing as

they compared their activities, etc., from the six disciplines of their program. The seminar also provided a place for the faculty to see where students were in relation to other parts of their program rather than just with respect to their own courses. And with both faculty and students present, there were opportunities for exchange of views and communication of experiences.

In attempting to view these activities in terms of a learning-cycle, it seems that much of what might be considered as an exploration happened before the seminar meetings and in the specific course activities that students engaged in. The seminar was the occasion, however, for their verbalizing about those activities so as to invent ways of putting them together, seeing them as similar and yet different from one another. It was also a place to hypothesize out loud about professors' strategies and to compare valuation schemes that they found being used.

If discovery happened in the seminar meeting, it usually was merely verbalized for sharing with others there and then awaited testing-out in out-of-seminar activities. Yet the reactions of his peers to the student's shared discoveries provided a helpful incentive for getting clear about his own thinking.

Seminar sessions during 1975-76 touched on many concerns including such questions as: What are your problem-solving processes like--comparing problems from different courses? How are grades regarded by you? What are their significance? What did you expect college would be like and is it what you expected? How do you organize work in small groups--compared to work individually? What are your expectations in classes, courses, etc., for your next year in college?

Though questions often focused on cognitive matters, the students' ways of handling them in seminar revealed something of their emotional reactions to various elements of the whole situation. Thus faculty were informed as to the extent to which emotional investment in the situation was making it difficult for them to reach equilibrium on intellectual matters. It became apparent that the students' responses to cognitive problems were related to their own ways of seeing themselves as persons. If they felt confident about themselves and comfortable with their own identities, then they could separate their successes and failures in classroom problem solving from their worthiness and integrity as persons and they were more ready to take risks in the concrete learning-cycle activities of their classes. Thus the sorts of interrelationships of the affective, the social, and the cognitive aspects of the students' growth that Piaget acknowledged in Six Psychological Studies (1967) was often expressed in students' seminar behaviors. For example, hostility toward professors was accompanied by "I can't do it!"-body language when students found

themselves in an "I don't know where to put it!"-quandary with respect to a required class activity. Then, as they rethought to "Maybe I can do it!" and began taking intellectual risks in trying ways to sort things out and, in that way, received feedback on their trials, they found they made progress and were less hostile toward the professors.

Whether or not the activities of the seminar are fittingly called "philosophy" is an open question among today's philosophers, for there is by no means unanimity in approach within the field as to what constitutes philosophy. It is clear, however, that some goals for the seminar coincide with the traditional views of philosophy, since aims for the students were to approach some synthesis of the ideas they were to pick up from their courses in the six specific disciplines.

Our way of structuring the seminar activities was, however, loose enough so that no specific philosophical position or positions was to be the outcome--students were encouraged to find a way for themselves and to imagine the behaviors and the valuing patterns that they would be committed to if they adopted certain stances. This is introductory philosophy as Piaget would view it, judging from his remarks in The Place of the Sciences of Man in the System of the Sciences (1974):

Since philosophy attempts to encompass the whole of reality, it necessarily bears two characteristics that constitute its true originality. The first consists in not dissociating questions one from another, since its specific purpose is to aim at the whole. The second is that, in the attempt to coordinate all human activities, each philosophical position implies evaluation and commitment, which excludes the possibility of any general meeting of minds to the extent that the values involved are unshakable (for example, spirituality or materialism, and so on).

If one adopts the view of philosophy suggested here by Piaget, there is clear justification for the establishment of the philosophy course as one of the credit-bearing courses which constitute the Piagetian program. And if it were made open to participation by the faculty as well as the students, such a class might easily be used as a place for monitoring the logical behavior of the students just as the ADAPT seminar was used. Further, in such a course the student could be challenged to analyze formally his own logic and to formulate his own world-views to achieve an economy in his own processing of the compartmentalized "reality" presented him through the subject matters distinguished under the

different "course" headings. In addition, the student might be encouraged to become aware of the valuation patterns within his decision making existence and in the implications of various strategies.

With such a course, not only could there be a testing of the program and the Piagetian principles on which it centers, but also an important test of a philosophy oriented use of the genetic epistemology could be accomplished. At the least it would provide some documentation for the claim of Henry L. Ruf (1976) that "philosophers have the capacity to teach people to think clearly and thoroughly" within a multidisciplinary, developmentally oriented college program.

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CHAPTER EIGHT

Content Versus Reasoning:

A Physics Instructor's Struggle

R.G. Fuller

Whenever I am asked to teach a physics course, I know what content I should cover. Even if the college catalog description of this course is brief and couched with generalities, I have a professional assurance that I know what physics topics to teach. During my years of graduate training and physics research I have come to embody the orthodoxy of physicists. Name a physics course, such as thermodynamics, or modern physics, or general physics, and I can immediately think of a list of topics to be taught in such a course. I can also name a textbook, or two, that can be used for each course. Consider a course called general physics. No doubt it includes the topics of mechanics, heat, sound, light, electricity, and magnetism, and modern physics. Probably with the topics taught in the sequence I have just listed. While my colleagues in physics might argue with me about a few items to be included in each topic, we would share broad areas of agreement about course content. That is one comfort to be found in being a physicist.

This orthodoxy of physicists is not based purely upon blind faith. After all, energy is a central concept in physics. In a general physics course energy and its various forms should be given a major role in shaping the course content. But energy is a quantity that can be calculated from the various properties of a system. Energy is calculated from the forces and the motions of a system and its parts. Then the study of forces and Newton's laws of action must precede a study of energy. But before we consider the action of forces which cause objects to move, we should know about the properties of moving objects. We need to study kinematics. So there you have it, a linear chain of topics leading up to energy, i.e., start with kinematics, through forces and Newton's laws, to energy.

Energy is a computed quantity, not directly measurable for any system. Nevertheless, concrete examples of systems with more and

less amounts of energy can be demonstrated for students so that the concept of energy can be made reasonable and concrete for many students. In the usual linear chain of topics, a student will need to understand forces before studying about energy. Forces do not seem to be difficult. After all, a force is just a push, or a pull, on an object. But the same size force acting down on a table top can have a different effect from a force acting horizontally on a top of a table. The quantitative effects of a force are complicated by the vector nature of forces, i.e., the effects of a force depend upon the direction in which the force is acting. Suppose you have two forces acting on an object and each force has a size of three; the net effect of these two forces added together is equal to a single force with a size from zero to six, depending upon the relative direction of the two forces. Therefore, forces, which serve as a content prerequisite for energy, possess a property which may make forces more difficult to understand than energy itself.

The effects of forces acting on an object can be observed in the motion of the object. So kinematics, the study of motion, serves as a content prerequisite for forces. Unfortunately, not only do such kinematic quantities as velocity and acceleration have vector properties, but acceleration is the ratio of a ratio, i.e., the time rate of change of the time rate of change of the displacement of the object. Once again, the prerequisite of a content area in physics (kinematics) contains reasoning tasks that seem to be more difficult than the subsequent content areas (forces and energy).

In short, topics to be studied in a physics course are arranged in a usual, or orthodox, sequence. This orthodox sequence has a rational basis, but this basis may not include a consideration of the level of reasoning required to learn each topic. A physics course which is used to foster the development of student reasoning abilities must progress from lower to higher reasoning levels. Consequently, such a developmental physics course may have a sequence of physics topics which contrasts with orthodox physics courses.

The ADAPT program presents a curriculum development problem to a physics instructor. One needs to design a sequence of physics learning cycles for college students which will begin with concrete reasoning abilities and lead to the more advanced reasoning abilities while preserving the content integrity of physics.

After the first year of the ADAPT program I wish that we could say that we had been able to solve that problem. I think that we are a bit more like Thomas Edison when he reported that he now knew 299 things that did not work. So let us begin with some of the learning cycles that did not seem to be effective.

Forces and their components seem inaccessible to most students. Never have so many students spent so much time on such a small concept and shown so little mastery of it. Maybe the components of forces is not a very useful concept anyway. If the student would just use vectors and their components in economics or in English or in history (I wonder what the components of a revolution are and what direction does a revolution point?), perhaps the study of vectors could be more easily justified.

The use of similar triangles or simple trigonometric functions to compute unknown, unmeasurable distances did not come easily. We recognized that these exercises required the students to use proportional reasoning, so we tried to design them to provide as much concrete background as possible. Nevertheless, the use of triangulation for measurements left many of the students confused and they sought private counseling with the mathematics instructor. I believe that such experiments are close to the developmental ability of ADAPT students and that if we redesign our exercises we can show better success next time.

Experiments for concrete operational students that can lead to the concepts of potential and kinetic energy in mechanical systems were difficult to design and were not easily used by the students.

Some experiments provided data which required some transformation before a linear relationship between the variables could be found on a graph. In general, these experiments were not helpful. For example, the students collected pressure versus the volume data for a confined gas. The curve of the pressure versus the inverse of the volume is linear in Cartesian coordinates. The transformation of data into a different format (in this case, taking the inverse of the volume) was not learned by most of the students, even with substantial instructor input.

There were some experiments that seemed to work quite well. The metric system was made to seem necessary and useful through an international bartering exercise which also helped introduce numerous economic variables. Graphical techniques were stressed and the students did learn how to use Cartesian coordinate graphs to find the algebraic relationship between the variables for linear functions. They also learned to use both log-log and semi-log graph paper to determine the more complicated functional relationships of

$$y = Ax^n \text{ and } y = A 10^{mx} .$$

Periodic motion and simple harmonic motion were properly analyzed by the students.

When the topics that were successfully understood by the ADAPT students are considered, we find an almost random collection of topics usually covered in a general physics course. The topics used with success in ADAPT physics are a small subset of the usual course. The sequence of topics seems to lack a rational basis. Several more years of ADAPT teaching experience is needed in order to find a more satisfactory developmental course in physics.

In concluding this chapter, I want to try to generalize on my experience with the physics component of ADAPT and try to express my impressions about what has happened in the other ADAPT disciplines during this project. I would like to believe that professors who think formally about their discipline are able to sit down in a quiet place and carefully analyze the structure of their discipline into a sequence of topics that increases monotonically in terms of the level of reasoning required of the students. However, I think our experiences in teaching the ADAPT program indicate otherwise. We can evolve college courses that encourage the cognitive self-regulation process with the content topics of our discipline. The response of our students provides the disequilibrating force and, I hope, our continued efforts at improving our program keeps us nearly equilibrated. Finally, the task of evolving an effective college program for the development of college students' reasoning abilities is much larger than the ADAPT program. We want to encourage many other faculty members who are engaged in a similar evolutionary process to share their insights and successes with us. Then, at last, perhaps we can impose some order upon the apparent chaos of our present efforts.

CHAPTER NINE

ADAPT Anthropology

M.Q. Peterson

INTRODUCTION

ADAPT Anthropology is focused on the discovery by the student of various social "rules" that govern his or her own social relationships. These rules are informed by the student's experience and observations. This combination of observation and participation is a traditional method in anthropology. Students are encouraged to put their questions into a "scientific format" of hypothesis testing. Minimal statistical methods are given beyond chi-square and the notion of random events. The students keep track of their work in a journal which becomes a means of final evaluation. No tests or examinations are given.

In this essay, I examine some of the ways in which students learn and some of the results of this learning, that is, what I have learned.

LEARNING EXPERIENCE

Students are in charge of learning how to investigate. This means that much of the time the student is not sure that he or she is doing "right." There are very few "right" answers and a lot of answers that seem to "fit" different students. I think that this experience is a necessary one for students to understand what is actually happening in much of human social behavior.

This notion of what "fits" for the student is at the core of my approach to ADAPT Anthropology. If the student's experience is important to his or her learning, and I believe it is, then it is important to validate that experience in the student's terms. Rather than look for what other people think is relevant and critical, the student searches for events, items of behavior, that they find interesting, important, or worthy of attention. They then investigate that behavior in the context of their own life.

In contrast, most books offer other people's stories in other places, often phrased in such academic fashion as to be neither

interesting nor important.

EXAMPLE OF CLASS PROJECT

I asked the class to figure out how college students greet each other in informal circumstances. Initially, I had asked how students greeted members of the opposite sex, a mistake I shall not soon live down, but more about that a bit later in this essay. This assignment created some confusion and apprehension, for, after all, "You just say, 'Hi.'" I told the students I was looking for a complete description of the way in which they greeted their friends, to specifically describe distance, eye contact, body movement, gestures and emotions.

After trying out some greetings in class with each other, they went out to the student union to collect some data, working in pairs usually. The next class period, they brought in their first observations. One student told me, "I was about 10 feet away from a guy, I made eye contact with him, smiled and he smiled back." This seemed to me to break into the following steps:

1. At about 10 feet, I make eye contact with the subject and smile.
2. The subject returns the smile.

This is an incomplete description, and I asked the student to clarify it by being more detailed and tell me next time what the subject did when the student made eye contact. Next class, the student said, "I made eye contact, the guy made eye contact for a very short time, looked away, and then looked back at me making eye contact again. I smiled and then he smiled.", Cr:

1. I made eye contact. (At 10 feet?)
2. The subject made eye contact with me for a short period of time.
3. The subject looked away.
4. The subject looked back at me and made eye contact.
5. I smiled.
6. The subject smiled.

This is an important move by the student. He is now making observations that are sufficiently detailed to ask two important questions. The first is, "What behavior goes just before that

observation and what behavior comes just after that observation?" The second is, "What behavior occurs when that observation you just described does not happen?" For example, I asked, "What occurs when you make eye contact, the subject makes eye contact, looks away and does not make eye contact again?"

This sequence of observations, questions and experience led the students to the following formulation of student greeting:

1. I look towards people walking towards me, that is, I turn my face towards people.

2. I find a person who I will try to greet.

3. At about 10 feet, I make eye contact with the person that I intend to greet.

4. I make eye contact for a short time period.

5. The subject turns his face towards me.

6. The subject makes eye contact with me for a short period.

- 6a. If the subject does not break eye contact with me, I feel him stare at me and I look away and do not greet him.

7. The subject and I make eye contact again for a longer period of time.

- 7a. If the subject does not make eye contact with me again, I do not do not greet him.

8. I smile.

9. The subject smiles.

10. If the subject smiles, at about 3 feet, I say, "Hi." If the subject does not smile, I do not say "Hi."

11. Just as I say, "Hi," I break eye contact and continue walking.

12. The subject breaks eye contact at the same time and also continues walking.

Using this sort of observational technique, I have found that students are able to generate their own rules of what other people actually do and do not do. This assignment led one student to discover what the rules were that allowed him to greet new people in social situations that otherwise were completely new. He put a sequence of behaviors together that showed him when his own behavior was effective and when it was ineffective, and then learned to modify his own behavior to maintain its effectiveness.

This sort of learning seems to me to demonstrate understanding of the operation of the student's social system, that is, the anthropology of his own social system.

BASIC CONCEPTS

I am trying to structure the experience of the students so they may learn a few basic concepts and techniques. If at the end of an academic year, most of them use the concepts and techniques, I am satisfied.

One of these basic concepts is human variation in social behavior. In my experience, many, if not most, of the first year students have narrow ranges of what to expect in social behavior. I think that I am not incorrect when I perceive that much of social behavior is sorted into "good" and "bad," or "acceptable" and "not acceptable." In my class, one important sorting criterion is "threatening" and "not threatening." In order to develop an awareness of "normal" variation in social behavior, I set up tasks that require students to look at common activities, done on campus, in public, between students, around the student union. As a biological anthropologist, I tend to see all behavior as "normal," and I am more interested in the relationships between behaviors and people than I am in the sorting of any set of behaviors into pre-existing categories. My students often seem to be much more interested in sorting and categories.

One of the advantages of this approach, I believe, is that students start to get a notion of non-random interactions among events and look for patterns and relationships rather than simple cause and effect chains. The idea of random and non-random is a powerful concept to many students.

"Essay on 'Random': Randomness is important in hypothesis development because it helps to decide if a idea or hypothesis is even worth testing. If an idea is shown to be random, there will be little use in trying to test it. It won't necessarily be trivial, but near to it, because one could expect random results everytime.

Chi-square is most useful in determining random occurrences. By plugging data in a chi-square where the expected has been set at a random 50-50 (or other equal divisions among the variables, $33 \frac{1}{3}$, $33 \frac{1}{3}$, $33 \frac{1}{3}$, etc.) it becomes possible to determine if the data is random. The probability resulting from the chi-square will reflect the "randomness." The smaller the probability (5 percent or less), the less likely it is to be a random distribution.

The idea of randomness is useful in developing an 'expected' for data which one doesn't have an expected for. This expected is important in any further data collection or analysis. The expected will end up as just another chance pattern other than one could expect by chance. If it does reflect 'non-randomness' or patterns other than those of chance, it may be useful to pursue the further study of your data and hypothesis." (Excerpts from a journal of a 19 year old student.)

I think that it is important that you know that this essay was not in response to any direct question that the instructor asked. Further, none of this information was given in class. This student has figured out how randomness and chi-square might be useful in the student's own investigation.

Another concept that I find important is that humans behave in structured, orderly ways. In general, I have to fight the nihilistic view that all of social behavior is learned and differs with the experience of each individual in the class. That is, everything is different and, so, cannot be investigated. Another rendering of this approach is found in the statement that it is "not fair" to study human behavior. If I understand what various students have tried to tell me about this, we all learn how to behave, so all investigation into behavior is part and parcel of learning how to control human behavior.

"I first must question your motive for assigning that rules for door-opening behavior, based on observations of that situation. I would think that you would expect that, once these rules are established, they should be followed, even though this has only been implied by you in class. After all, in any situation where rules have been set up to govern and control one's behavior, these rules are expected to be enforced (or perhaps a

better work would be 'followed'). Look at the Ten Commandments in the Bible: Are these not rules by which man is expected to live? ('He who keeps the commandment keeps his life; he who despised the word will die.' PROVERBS 19:16)

I would then conclude that making a list of rules of door-opening behavior would directly (but perhaps not even consciously) affect one's own behavior. I would have to take issue with Julie's comment that "The objective is not to change our door-opening behavior but rather to simply make us aware of what we are doing, how we are interacting with others." I would definitely say that you are in fact trying to change our behavior in interactions with other human beings, or are at least trying to establish an 'ideal set' by which one or all should follow if one's behavior is to be accepted." (Excerpt from journal of 19 year old student.)

I am not clear whether the problem lies in the student gaining control over another's behavior or, as I sometimes suspect, in learning to control his or her own behavior. In any case, I have had continual problems with this issue.

A third concept, certainly on a different level, is that human behavior can be investigated by students in an easy and fruitful manner with a minimum of instruments without invading the privacy of others. While the course is directed at understanding certain human social behaviors, the metacourse is directed at teaching students techniques for recognizing the social behavior of themselves and others, investigating that behavior, using their emotions to place value on that behavior, and constructing methods to learn about that behavior. Some of the students recognize this quickly, while others never seem to understand that they can apply this method to other aspects of their world. Still others already have all of the answers about social behavior that they want or need and cannot handle further questions.

"Watching people this year (doing a little of everything) has answered some questions, made me understand other questions, and let me be able to ask more. I did not really put all of my attention on doors. But I do feel that a person's mood and background have a lot to do with that person's reactions.

I wonder if one can prove that different behaviors occur because of different back grounds? Is this true or not on campus? Look at all the variation of people that attend college.

This semester has been unreal, mainly because of people I have met and events which I thought I would never let happen. From and for myself, I feel and will say that setting goals, values and moral standards is good, really safe, and leaves one feeling secure (sometimes). I have decided that to do such things takes the risk out of life...how else is one to learn of the immediate world...I know I may never know as much as I like or as much as other 'SMART' people, but that is not really important. I feel that knowing enough to base a fair opinion on some subject is important. I have decided not to judge people like I did in the past, but I now generally wonder why they do what they do." (Excerpt from journal of 18 year old student.)

At the end of the semester, I am happy if my students are aware of some orderliness in human social behavior, identify behavior that is meaningful to them in themselves and others, and have some sense and experience in how they may investigate such behavior for themselves.

FORMS OF STUDENT BEHAVIOR

I identify three different forms of student behavior in ADAPT Anthropology. The first form is characterized by no work being produced. The second form has "results" produced, but the actual data are a product of either premature generalizations or fantasy. The third form is seen by hard work and limited results.

The student who is "stuck" can not, will not, or does not work in such a fashion as to have experiences which he or she can use to generate notions or ideas. Some of the behaviors associated with this include making up observations and faking data, being bored, restless and inattentative in class or simply absent from class a great portion of the time. I have not hit upon a solution to work with this kind of behavior. To the extent I take responsibility for the student's work, the student does my version of work, not his or hers. I avoid this and let the student either work or sit.

The next form of student behavior is one that I see as "fantasy." This behavior includes rejection of personal experience and methods of direct observation. Social behavior is seen in

gross catagories with premature and superficial generalizations. The person who exhibits this sort of behavior is difficult to deal with in such a program as ours. He is comfortable with what he already knows and is not willing to have new experiences that may disconfirm his reality. One person expressed this view very well:

"I grew up in a town of 180 people, and I guess that I know everything that is worth knowing already." (Statement in class by a 19 year old student.)

My own feeling is that my notion of fantasy is not an adequate way to describe this person's formal operating ability, but in practice, this may be the way that this person sometime operates.

The third form of behavior is characterized by risk taking, error, counting of events, simple and even complicated hypothetical notions, confusion and continual questions. These people discover rules that work for them, the context of those rules and that the rules are usually not universal. Anxiety over continual uncertainty, present during the first part of the course, is generally replaced by a confidence that although the rules may change, the student has the ability to find out not only what the new rules are, but a good idea of how to go about learning how they operate. This allows the learning to be an actual part of one's life.

"Anthropology deals with the study of man---and that's what we've been studying---man---but more specifically behavioral patterns. In door-opening behavior---as well as hustling, eye contact, etc---we found many relationships or rules---that link together---these I have generalized as maybe some of the generalized rules of life.

Which brings me to my next point---you can't list the rules of life---its too big and too vast, a subject that one could look at as a whole and say---this is the way it usually is, etc---but when looking at smaller aspects of life---such as door-opening behavior, its much easier to make rules and test them. Then if these rules are proved maybe they can be applied to different situations---and different aspects of life." (Excerpt from a journal of a 19 year old student.)

This method lets people know that they are at the center of their learning, not just outside observers. I think that this is a powerful move.

GENERAL COMMENTS

I believe that it is important that the rules and behaviors that the students learn about are in the "real world," not in arbitrary rules known first to the instructor, and then to the students. This prevents students from playing the game of "read the instructor's mind."

Active participation of the student is required. Without observation and experience, the student will remain at the pre-concrete level of operations. In other courses outside the ADAPT Program that I have taught, many students who are not willing to experience through their own investigation, choose to read instead. They claim that they learn more by reading than they do by experience. I am less sure. My experience is that they often have an improved vocabulary, but remain at a fantasy level in their operating ability.

No absolute generalizations are sought. In this regard, ADAPT Anthropology is not similar to other ADAPT courses. Students observe and experience the world in ways that fit for them. The formal rule of an attractive, self-assured young woman is not a formal rule for the behavior of her male counterpart. It is the multiplicity of social rules that are context specific that makes social science so difficult to learn, I believe.

Because there are so few "right" answers, I have found that having the students compete with each other on the basis of the robustness and power of their generalizations is a method of having students become peer teachers. This also has the advantage of forcing the students who are using fantasy or fake data into either active participation or passive resignation.

"...I have not been participating in actual day-to-day assignments. For this reason, I feel that the whole second semester in Anthropology has not been applicable to me at all, and has been a waste of time for me for the most part." (Excerpt from the journal of a 19 year old student.)

Many students have come to my class with full formal operational schemes that encompass most social behavior between members of the same or opposite sex. These formal rules come out of their peers, parents, and religion. I gave an exercise on

greeting behavior that I had the poor judgement to call "hustling behavior." The anxiety level shot up, the observations and experiences came to a halt and we spent a month in the exercise of conventional wisdom and metastories about how risky it was to meet new people and the danger of strangers.

Finally, I am not sure of the value of text books in the context of my ADAPT Anthropology course. I think of text material as "clear" and "not clear." The degree of clarity seems to me to come out of my experience. Without experience, I think that I may share a fantasy, but I suspect I do not understand, except by chance or fortune, what the author understands. We often seem to have implicitly accepted the notion that since words have meaning, sentences give meanings, paragraphs replace experience and books are wisdom.

Wittgenstein says this better: "Philosophers who believe you can, in a manner of speaking, extend experience by thinking, ought to remember that you can transmit speech over the telephone, but not measles." (Ludwig Wittgenstein, 1975 PHILCSOPHICAL REMARKS Blackwells, page 95.)

I distinguish between my concepts of learning about and learning. A concrete example will help. All of us have been exposed to the Gardner's studies of Washo, the chimp who "speaks" American Sign Language. Depending on your prior training and present judgment, you may think that their work demonstrates that Washo has language ability, does not have language ability, not know or not care. In any case, regardless of your view you know about Washo's language ability.

In contrast, I know that Washo has language ability. I know in the same fashion that the Gardner's know: I spent a year working in an enclosure with two gorillas on a project the basis of which came from the same source as the Gardner's. I demonstrated to myself that the gorillas and I shared much of the same language system.

I wish to forstall any arguments that I may be wrong. Of course I may be wrong. You may not believe that my experiences demonstrate that gorillas have language ability and you may question my perceptions. The point is that I was an active participant in my learning cycle, not a passive reader in the Gardner's learning cycle. Because of this, when I find I am wrong, I will learn something new. Without this, I doubt that I would ever be able to "know," and I wonder if I would be able to "learn," that man and higher primates share much of the same language system.

I believe that I am questioning the heuristic use of text books alone, without appropriate experience, as a method of teaching or learning. Please do not feel that I am attacking any of us. I teach the largest class in my department out of a text book, with no experiences, appropriate or inappropriate. The students can answer all the questions, but I am not convinced that any of them have the experience necessary to formally operate with the concepts they memorize.

At these times, I wish I taught an easy subject like math or physics.

In summary, I think that the fantasy level is demonstrated by inability to get experience or make observations, using imagination instead.

I think that the concrete level of operations is demonstrated by collecting specific data related to few variables and reporting those variable without any notion that they are either context specific or limited in generalization.

I am not comfortable that I can easily differentiate various levels of formal operations. In general, the "formal" responses acknowledge 1) context of behavior, 2) variation in behavior, 3) discrete variables of behavior, and 4) combine these elements in sequential relationships to generate limited notions or hypotheses. They then test these notions by their own actions and the actions of others. Finally, they ask further questions.

A benefit of this approach is that we become a person who is part of the process of learning, rather than a "teacher," a person above and beyond the student and the experiences of the student. We are, then, an integral part of a learning cycle that includes our learning. I believe that this has advantages for us all.

CHAPTER TEN

Reading and Writing and Piaget

R.D. Narveson

Like most English teachers I have been skeptical of schemes to reform the teaching of literature and composition. Our experience suggests that for the most part our successes are likely to result from the intangibles of personal styles, developed empirically through classroom practice. As Ross Winterowd has written, "One can only conclude that writing is far too difficult a skill to be taught--and yet we do teach it." (1975, p. 20) Nevertheless, I seized the opportunity to join the ADAPT program because it seemed to offer a more thoroughly articulated theoretical basis for teaching and learning than I had previously experienced. The program was particularly attractive because it provided a context within which one could proceed intelligently from the insight that what we do is not so much to teach writing or critical reading as to stimulate students to develop their capacities to write effectively and read critically. In the crucial matter of providing an environment favorable for learning, the ADAPT staff would be guided by Jean Piaget's theories of human intellectual development. Within the diversity of courses we would offer, we would try to provide a more coherent structure of experiences than students usually encounter at a large public university. I expected no miracles. I foresaw, nevertheless, a promising setting in which the general intellectual maturity of students might be enhanced, and thus their particular capacities as readers and writers as well.

There was truth in the hard response of one colleague of mine when an earnest student asked what would improve his English skills. "Sunshine and vitamins," was what he said; "sunshine and vitamins." For it seems that maturation of language skills is intricately bound up with a person's whole intellectual development and "cannot be hastened apart from that development" (Kitzhaber 1963, p. 26). But when we speak of "intellectual development" most of us have in mind something rather global and undefined. Lacking agreement on what specific skills, processes, or perceptions might mark a mature mind, we as educators have found ourselves encouraging disparate aims without much sense of their

priorities or relationships. It is refreshing to find in Piaget an unusually specific and precise description of some of the mental operations that typify human behavior at different stages of life. These operations, he has shown, always develop in the same sequence. The mental processes characteristic of maturity he calls formal operations. He does not suggest that our intervention alone can speed minds to maturity. But his work does help us to plan a variety of stimulations to nudge our students in the direction of mature thinking.

Piaget's descriptions of human intellectual development are derived from observing how children use logical processes to make sense of their physical experiences. He has had comparatively little to say about the emotional or imaginative life. It was therefore clear that however much the work of Piaget and his interpreters could aid in the task of teaching reading and writing to college students, I should not expect the same degree of guidance as might my colleagues in the physical sciences or even the social sciences. The ADAPT program did nevertheless allow me to share with them at least the following four objectives:

- 1) To replace, wherever possible, patterns of passive receptivity with patterns of physical and social as well as intellectual activity.

- 2) To exploit peer-stimuli to learning available when students work together for several hours each day.

- 3) To foster student initiative in problem-stating and -solving by the use of "learning cycles."

- 4) To adjust student tasks to their present levels of intellectual development while offering appropriate challenges to grow to higher levels.

Each of these objectives is a large subject in itself. My comments on the first three will be brief.

Our first objective, to make learning physically and socially--as well as intellectually--active, accords with the Piagetian theory that all intellectual activity, even the most sophisticated, has its roots in sensory-motor experience. It is far easier for an English teacher to neglect this radical connection than to exploit it. I looked with envy at the apparatus available to the physics teacher and the simulation games inventively employed in ADAPT economics and history. How could one introduce comparably concrete activities into the composition and literature classroom? And even if one could, would it be worth the time and effort? I soon learned, delightedly, that there are some simple activities that are a great boon to learning at least some

things about literature. I learned, for example, that after students had sprawled on the floor in groups, arranging a bunch of cards with words on them into the form of a limerick, they had internalized far more about meter, rhyme, stanza, and grammatical nuance than twice the time spent in purely verbal exercise would have taught them. Attaching muscular movements and physical arrangements to these mental concepts caused the concepts to stick better in their minds. Furthermore, they developed a better sense of the variables a poet must manipulate, and so respected poetry more and found it more challenging.

True, any psychologist could have predicted these results, but I had not learned the lesson so graphically in twenty previous years of teaching. Why had I never learned before that students respond more powerfully to Mark Twain or Jane Austen if they simply spend part of their class time seated in a circle taking turns reading aloud to each other? So help me, this was college, not grade school, yet it was so.

I must acknowledge that it was not an easy task for me to devise suitable physical and social activities to accompany the conceptual learning that was the primary objective, but I was encouraged by such successes as these to keep looking for more.

In pursuing our second objective, it was to my advantage that various methods of encouraging peer-group activity are now staples of English classroom practice. As it turned out, the sort of small-group investigations of literary works and of student papers that I have used for a number of years proved even more effective in the ADAPT classes. The reason is plain. Students, like people in general, hesitate to reveal to strangers the intimate feelings that are a central part of genuine literary experiences. But as they come to know their fellow students, they become more relaxed in their company. They become willing to speak and to listen. Most literature and writing courses, though small enough to encourage intimacy, meet for only three hours each week of the semester. By contrast, ADAPT students were together in small classes for about twenty hours each week.

As for our third objective, I saw many advantages to teaching writing and critical reading as essentially problem-solving activities. Viewing writing from such a perspective encourages students to use the writing process to discover and order their thoughts about matters of concern to them. It helps them to fit the activities of the English classroom, such as their explorations of their responses to literature, into the patterns of their other classes, where they are working to explore and order other aspects of experience. It makes them address an audience (i.e., their peers and their professor) whom they know to share their interest in mastering their experiences. Addressing such an audience, they

are discouraged from pontificating and dogmatizing and encouraged instead to frame and test tentative hypotheses. The sense of sharing an investigation with others likewise engaged encourages them to find value in their own observations and opinions and to lessen their passive reliance on authority. Their desire to share leads to the search for and discovery of rhetorical solutions to problems of selection and ordering, and their solutions to these problems are more meaningful because arising from their felt needs rather than, as frequently, from the instructor's lesson plans. One final and significant advantage: the problem-solving approach is, as Lee Odell (1973) argues, a fairly direct application of Piaget's notions of how people learn.

If one expects students to employ a problem-solving approach to their writing, one should familiarize them with such an approach in their classroom activities. Each of us attempted to do so in his own discipline. Our formal device was the "learning cycle," described in "The Teacher's Guide to the Learning Cycle" found elsewhere in this volume. One of the most difficult challenges of our program, never completely met, was to arrange planned activities in learning cycles that began where I wanted them to and ended where I wanted them to. But if the teacher can be flexible and adaptable enough to pick up student cues, the learning cycle of exploration, invention and application can frequently be improvised on the spot. Such learning experiences, as everyone knows, are frequently more significant than those planned ahead of time.

The fourth objective, to adjust tasks to current levels of development while appropriately challenging students to grow, is perhaps a crucial one to the ADAPT program. Are the stages of intellectual development, as Piaget has defined them, real or even approximately real? If they are, can we describe specific tasks that demand specific stages of development for their successful completion as Piaget does in his writings? Unfortunately, to quote Winterowd again, "the 'factors' involved in writing are overwhelmingly numerous and largely unknown" (p. 20). Piaget has concluded that there is a final stage of intellectual development, the stage of formal operations, marked by the ability to perform certain clearly definable operations. Yet some students who can perform physics and chemistry tasks requiring such ability are not good writers; nor do all good writers perform well at those tasks. We can, to be sure, define sorts of writing behavior that are accepted as marks of maturity. We have always done so. But we have done so without Piaget, and so far at least, it is not demonstrated that he can help us to do so any better. Yet, the

idea of clearly demarcated stages in human intellectual development is an attractive one and makes worthwhile the attempt to define, within the lesser degree of precision allowed by the subject matter, some specific tasks required in essay writing that may relate to Piagetian levels of development. The pages that follow describe one groping effort to do that.

For three weeks in November the students in the ADAPT program worked with Mark Twain's novel The Adventures of Huckleberry Finn. In addition to discussing the novel in class, they wrote about it in their journals and wrote short (two- or three-page) papers, which in most cases they rewrote after submission for criticism both by their peers and by their teacher. On November 24, to conclude their work with the novel, they wrote essays in class discussing questions chosen by class vote from their own suggestions. The essays that resulted differ widely in quality, as might be expected; and the differences in quality may reflect any of the usual differences in preparation, previous training in writing, or natural talent that distinguish one person from others in a group. Because of the considerable time and class attention given to this novel, I assume that level of preparation is not highly important in accounting for the differences in the essays. If the essays reflect with some accuracy the competence of the students to explore systematically a question about material that is familiar to them, it should be interesting to see how they go about the task, and to ask whether their ability to perform the task relates to the stages they have attained in Piaget's developmental scheme.

The symbolic code that we call language is marvelously complex. It is complex in its spoken form, it is complex in its written form. The two forms are closely related but significantly different. Human beings produce the spoken language spontaneously; for most, this is not the case with the written form. The gestures, expressions, and variations of pitch and stress that aid spoken communication are mastered by most people through constant spontaneous practice with instant corrective feedback from other people. Writing is a solitary act, for the most part; the writer must imagine the response he will get from an audience that for the most part he will not see responding. Used to producing without conscious thought the countless little signals that give nuance to his words, he finds it hard to adapt to the very different signals that his written message conveys through vocabulary choice, syntax, and on down through spelling, punctuation, and mechanics. And as if all this were not troubling enough, the student at the college level is asked to produce not only discourse that is communicative and expressive but also ordered to represent the efficient carrying out of intellectual tasks.

In the preceding paragraph I have described the task of representing an ordered working out of an intellectual problem as if it were imposed on top of the other tasks of writing, such as producing individual utterances that are both communicative and expressive. We are encouraged to think this way because people can do produce writing that is beautifully communicative and expressive and yet is not orderly or coherent on a large scale. Who does not appreciate a good wise crack, or a joke, or a vigorous

expression of pleasure or antipathy? But it may be equally, or more, accurate to think that the situation is just the other way around: the mental grasp of order and system that gives us control over our experience may be present even though we cannot, or have not, produced the writing that communicates our understanding to others. In fact, how will we know what sort of sentences and paragraphs to produce unless we have some notion of the order and coherence we aim to communicate? Or, what seems even more likely, the processes of understanding what we want to say and the processes of producing the writing that says it may be intertwined; they may go on together. It may make sense to say of someone who does not know what to write that he does not know how to act. An ambitious attempt to attack the teaching of writing using this assumption is described by Zoellner (1969). But Zoellner is handicapped by his behavioristic assumptions. He has no theory of what goes on in the mind. For such a theory, the ADAPT staff has chosen to turn to the work of Piaget and his followers.

Through many years of painstaking observation and questioning of children, Piaget has worked out a schema for describing how human intelligence functions. Observing that intelligence functions differently at different ages of the same individual, he has proposed that each person passes through a number of distinct stages, which he has described. But he has done more. He has described how people learn, grow intellectually, and pass from one stage to another. His is a developmental theory. The ADAPT staff finds Piaget's theory attractive because it suggests that we can relate student performance to student intellectual development rather than to student intelligence as measured by IQ tests. It suggests, in other words, that our freshmen are still learning through a process of maturation as well as through concentrated efforts to master particular subject matters or skills. If this is true, what can be taught will depend to some extent on the stage of development a person has reached. It will be fruitless to try to teach a person skills and intellectual constructs that are still beyond his grasp. In general, intelligence is too little understood for anyone to define any person as being at a given stage in all respects. Particularly after adolescence, a person may be at one stage in dealing with one sort of experience, and at another in respect to others. Nevertheless, if the theory is to be useful, we must identify at least some characteristics of mental operations at each stage. It is with this imperative in mind that I have looked at five of my students' essays, to see whether they reflect certain modes of operation that I can associate with Piagetian stages of development.

Piaget described the last two stages of intellectual development as the concrete operational stage and the formal operational stage. He defined the concrete operational stage with reference to tasks that children could carry out successfully after

reaching a certain age, but not before. At the concrete stage the child performs mental operations involving objects. Piaget summarizes these operations as those of classes, relations, and numbers (Piaget, 1964). The age at which concrete operations develop may vary; in this country it is usually somewhere between six and eight years. The formal operational stage is defined with reference to tasks that a person in the concrete operational stage does not perform successfully. A person at the formal operational stage, Piaget says, can "reason on hypotheses, and not only on objects." I interpret this to mean that he can reason with concepts that cannot be referred in an immediate or simple way to physical reality. For example, in looking at a swinging pendulum, you cannot "see" that it is the length of string, and not the weight, the arc of swing, or the vigor of the push, that controls the period; you have to reason out the possibilities and test them against experience. The ability to perform formal operations supposedly develops somewhere between the ages of twelve and sixteen, in most people.

According to some studies as many as fifty percent of college freshmen who are asked to perform Piaget's tasks that show formal operations are unable to do so. He has speculated that young adults may be formal operational in areas that interest them while remaining on the concrete operational levels in other areas (Piaget 1972). If this is so, we need different tasks to identify the levels of thought in each discipline. The problem for the English teacher is that all of Piaget's tasks are physics or chemistry based. Success in them is immediately and clearly confirmed by reality. By contrast the tasks in English classes require operations with language, and success is confirmed or denied by reference to other language. There may be operations with language that cannot be performed by those whom the Piagetian tasks identify as formal operational. That would be convenient indeed. But I do not know with any certainty what they are. In examining my students' essays about Huck Finn, the best I can do is to specify and describe some of the tasks involved in writing them, show that the tasks are performed more successfully in some of the essays than in others, and suggest, very tentatively, a possible correlation with the Piagetian stages attained by the writers.

The rhetoric text used in ADAPT English supplies me with a guide in selecting the operations to focus upon. In keeping with a current trend, this text, Rhetoric: Discovery and Change, by Young, Becker, and Pike (1970), spends much time on what is sometimes called "pre-writing" activity: finding a subject, defining an audience, determining the stance of the writer, and deciding how to handle the subject. It stresses the importance of understanding one's subject as thoroughly as possible by exploring it thoroughly and systematically, and it tells how to look and what to look for. This organized way of exploring is a "heuristic," a

method of finding things to say about any subject that one has information on. As any heuristic must, this one has many parts to it. The one on which we have spent the most time is the maxim that an experience can be understood only if three aspects of the experience are known: 1) its contrastive features, 2) its range of variation, and 3) its distribution in larger contexts. "Contrastive features" are the features, and combination of features, by which we recognize the experience and tell it apart from other things. The "range of variation" describes how widely some of the features can vary and still be part of the experience. "Distribution" refers to how often and where individual features occur as well as how often and in what contexts the whole experience occurs. Even apart from the rest of the system, a careful attention to these three aspects of an experience will produce a great deal for the would-be writer to operate with. Thus the first thing that I will look for in the essays is the evidence that the writer has attempted to understand his subject by examining these three aspects.

Such an exploration of a subject produces a mass of observations which are difficult to operate with because of their number and diversity. The data must be organized before they are useful. Probably the commonest device for organizing material is the "hierarchy," which consists of classes, subclasses, and superclasses,--as many levels of generality as desired. All college students classify, but students vary widely in their ability to choose productive systems of classification, to make clear distinctions between classes and levels of classes, and to keep classes and class membership constant. How the students work with classes is the second thing that I will look for in the essays.

The five essays are reproduced, warts and all, just as they were written. Any departures from the conventions of written English are the students' own. Each essay is numbered for easy reference. Rather than interrupt the text of my discussion, I have grouped them separately; the reader is encouraged to set the essay and my discussion of it side-by-side while he reads. (The reader is warned that the sex of the students may not be inferred from the pronouns.)

Each student chose his question from among three that were selected by class vote after each student suggested a question, but no student was allowed to write on his own question. The wording of the questions varies because the students copied them differently from the blackboard.

Essay 1. This student mentions a great many "contrastive features," particularly of Huck's life with the Widow, and in thinking about their "range of variation," decides on a high level

class-division into the categories of "restraint" and "freedom." He finds examples of both of these in Huck's life with the Widow, and also in his life with Pap. In the third context specified in the question he wants to find the same categories illustrated, and here he runs into trouble. To show that "restraint" is present in Huck's life with Jim he discusses the Grangerford incident, overlooking the objection that Jim is not with Huck at that time.

In his third paragraph the student very commendably decides to widen the range of considerations by introducing "civilization" and its opposite, for which he lacks a name. He calls the life Huck leads with the Widow and with Pap civilized, the life with Jim the opposite, but makes no distinctions between the very different life at the Widow's and at Pap's. In his conclusion he notes Huck's distaste for civilized life, but misses the chance to relate civilization to "restraint" and life on the river to "freedom."

I conclude that the writer of Essay 1 has made an effort to understand the three aspects of his subject. He has not seen a way to expand his range of contrastive features so as to describe more of the book, as he could easily do by finding traits of civilization in other episodes besides those involving the Widow. He has attempted an expansion under the headings of "freedom" and "restraint" only to run into distortions of the facts. A number of the most frequently occurring features of the book escape his notice, such as the religious elements, the superstitions, the confidence games, and the story-telling. As for his use of classes, the ones he sets up offer him plenty of scope. Further definition of each class, and the use of more and clearer examples, especially in the case of life with Jim, would be helpful to him and might particularly have led to a better relating of "civilization" to the other two classes.

Judged simply for its grasp of aspects that a reader of the novel may justly admire, the essay is only adequate. Too much is left out, and too much is left confused. On the other hand, its demonstration of some of the variety and particularity of the book is quite good.

Essay 2. In some ways, the question chosen by this student offers him fewer suggestions about how to proceed than did the question discussed in Essay 1. If student 2 is going to make comparisons and contrasts, he must think up his own classes of things to work with, whereas student 1 was given both the strategy and the classes.

The student begins by asking for contrastive features of "civilized" life that bothered Huck, and immediately finds large classes that fairly well exclude each other and that include a wide range of variations both among and within the classes. He is also

aware of the importance of distribution in contexts, though neither very conscious nor thorough about it. His answer covers more limited features of the novel than it could have because he does not go beyond the narrow range that the question suggests to him, except for some brief mention of the freedom and beauty Huck finds in nature but not in civilization. To be consistent and thorough in talking about Huck's likes and dislikes, the student might also have mentioned the things that Huck finds in civilization that are good, such as the "style" displayed by Tom and the Grangerfords, the affection shown him by the Widow, the Grangerfords, the Wilks girls, and the Phelpses, and also the abundant and mouthwatering meals he describes so lovingly. On the whole, despite some limitations, this essay succeeds in operating with clearer and larger generalizations without sacrificing the solid specificity of the first essay.

Essay 3. This student begins her essay, which deals with the same question as Essay 1, in a way that permits her to explore widely. She sets up the broad concept "life styles," explores some of the possible subclasses of features under that concept, and then identifies different "life styles" with each of the three characters her question specifies. The two broad sub-classes, "personality" and "social status" are further sub-divided, the latter to include "wealth, occupation, religion, and manners." The wide range of variation and the number of contrastive features that this hierarchical system encourages is very large.

In a paragraph devoted to each character, the student attends to each item under "social status" but does less than justice to "personality," though fortunately some personality traits do get mentioned as she is describing social traits.

Turning next to Huck's life with each character, the student asks how Huck must adapt in each case. Included is both outward treatment--beatings, neglect, care, instruction--and inner feelings--Pap's callousness versus the Widow's motherly affection. Life with Jim is described as combining the best of each of the other two situations.

In a final section the student extends the range of variation by looking at the constants of Huck's personality that persist throughout the variety of contexts described--Huck's "love of adventure" and "bright imagination." In summing up, the three concepts discussed are brought into clear and orderly relationship: social status, "treatment received from each person" (unfortunately almost too different from the earlier term "personality" for the reader to make easy connection), and Huck's personal traits.

This essay shows the student in firm control of a wide range of variables. The classifications are complex and clear. So much

of interest is found in the episodes discussed that one does not desire reference to more of the episodes. In the case of both students 2 and 3, I feel confident that just a little encouragement along with a little more experience will lead them to extend their answers to encompass more fully the material they are discussing. They show that they are in command of the mental operations that would enable them to do so.

Essay 4. This student chooses the same question as students 1 and 3, but reformulates it in a way that reduces its range by omitting Pap from consideration and eliminating the request for contrasts as well as comparisons. He begins his answer by setting up two opposing classes, "romantic" and "realistic." I note that having framed the question to ask for comparisons, the student sets up an answer that calls for contrasts. Of course, asking for both would encourage a wider range of exploration. The classes set up are on an extremely high level of abstraction. Sub-classes are then given for "romanticism": "freedom, self-reliance, independence, and heroism," along with being "individualistic" and going "back to nature." All of these terms have been used by literary critics in discussing the novel Huck Finn, and I hazard a guess that this student has either read some criticism, or heard a teacher use the terms, or both. Each can be used to shed light on the novel; this student assumes, however, that merely mentioning them does the job, as if the terms themselves served as keys to unlock meanings. The terms are not defined by reference to features of the novel, as was done in the preceding essay. In fact, in an attempt to develop the concept "romantic" the student turns away from the novel to the example of Rousseau's ideas about Indians. Jim is said to "represent" freedom, though how Jim does so more than Huck is not explained. Huck is said to achieve a feeling of power, but the example, attending his own funeral, is from Tom Sawyer.

Sub-classes under "realistic" include: Huck's having to "do what he was told," Jim's enslavement, racism, ignorance, and superstition. The list is miscellaneous; how each item is a feature of "realistic" life is not explained and would be hard to explain. For example, Huck and Jim are just as superstitious on the river as they are at the Widow's.

In the conclusion of the essay the subject is changed from the sort of life Huck lived to the personal qualities Huck acquired while living on the river. We are told that Huck was different at Aunt Sally's and at Widow Douglas's; but no instances are given of how he acts differently, and in fact his response to both situations is the same in the end: he can't stand being "civilized."

Essay 4 thus seems to me to illustrate what is produced when a student attempts to solve a problem by employing concepts that he has not internalized and made his own. The concepts are used because their use by authority figures recommends them, in the same way that a child understands that knots are used to tie shoe laces. In both cases a jumble is the result. Neither the child nor the student should be condemned for his efforts; on the contrary, both should be commended, and then their attention should be directed to activities better suited to them. If allowed to continue operating with high-level abstractions inadequately related to the student's own reading experience, the student will be denied the experience of having made his own sense out of his reading; he will confirm his belief that he cannot by his own mental efforts formulate valuable and true concepts about literary texts but must depend on those who preside over the mysteries to reveal the truth to him.

Essay 5. This student is also in difficulty. The case is more extreme than the preceding one. The shortness of his essay suggests that he literally did not know how to act. He sets down a number of contrastive features but, failing to attend to range of variation and distribution in contexts, he gets bogged down in the particulars of one episode. Finally escaping that trap, he goes to the opposite extreme of generalizing without supporting examples. The two categories employed, chronological age and level of maturity, are not explored in enough variety to offer much help in deciding what incidents to discuss. Instead of beginning his discussion by leaving the question open to various possibilities, he commits himself to a very limited position: Huck has changed, and in exactly two ways. He also quickly involves himself in a contradiction but apparently does not know it. He asserts that Huck is seven or eight years old at the start of the story and about fourteen or fifteen at the end; yet the story covers only a year. Possibly he has not read the story carefully and is not aware of the time scheme, but it is more likely that he has misunderstood what was said in class about how young Huck acts in the opening chapters and how much older he acts later on.

Like students 1 and 4, student 5 mishandles his classifications. In his choice of concepts for his higher level classes he is closer to student 1 than to student 4; both he and student 1 choose concepts that should be within their range of personal experience so that they can relate easily to them. Given encouragement, they should be able to select a broad range of features from the novel that fit their categories.

Can we draw any conclusions about stages of intellectual development from this analysis of five essays? It would seem that students 2 and 3 are operating at a level distinctly different from that of the other three students. I want to call it a more mature level. I feel safe in calling those essays productions of formal

operational thinking. But what of the other students? Do their essays manifest concrete operational thinking? Their difficulties in realizing the full possibilities of the heuristic concepts of contrastive features, range of variations, and distribution in contexts, and their even greater difficulties in conceiving and controlling a hierarchy of classes, may so indicate. If these writers are in fact operating concretely, the first essay, particularly, suggests that they can learn to produce acceptable discussions of literature if they are encouraged to respect what they know about human life from their own personal experience and to relate features of their experience to features of the texts they read. Of one thing I am fairly certain. The essay of student 4 confirms my belief that conventional literary criticism is not an appropriate model for all students.

No one doubts that students vary widely in ability. Not everyone agrees that some of the difference is due to level of mental development rather than "intelligence." That the differences of the kinds found in these essays are related to Piagetian stages of development is neither proved nor disproved. Lacking any clear knowledge of what accounts for the differences, we may assume what we please; but whatever we assume will affect our teaching practices.

Karplus (1974) has pointed out the implications of a developmental model for physics teaching: 1) a teaching program must offer prospects of success to students at different stages; 2) new topics should be introduced on a level at which students at lower stages can gain at least partial understanding of them; and 3) students at lower stages must be given encouragement so that they will gradually raise their level of operation. These operating principles seem equally applicable to the teaching of composition--and equally challenging to the teacher.

Essay 1

How is Huck's life with the Widow Douglas and Pap compared and contrasted to the life with Jim.

Huck's life with the Widow Douglas and Pap can be compared to the degree that he was restrained by both. While at Widow's Huck had to be all dressed up and be at his best manners all the time plus had to go to school and take lessons from Miss Watson. While with Pap he had to stay in the cabin most of the time because Pap was afraid of Huck running away. In both though, Huck had alot of freedom also. With Pap Huck alway went out to collect wood and bring in the fish and set lines and be out into nature which was his love. With the Widow Huck always got to sneak out at night and make fun of Jim and be with Tom, so really the restraint and freedom kind of equalled out.

That was the same way with Huck's life out on the river with Jim. Several times throughout the book he could have been considered in restraint, for example when he was living with the Grangerfords he had to wear dressy clothing again and had to go to church on Sunday, and again with the King and the Duke where he had to go along with them because he knew he couldn't convince Jim that they were phoney. Then there is the good side where while at the Grangerfords Huck could play with Buck and just have plain old fun, and with the King and the Duke Huck found them fun at first to be with but then it just got carried away and Huck knew he had to escape those two.

As you can see Huck's life with the Widow Douglas and Pap were quite simular to his life on the river with Jim but in different contexts. The biggest contrast between his life with the Widow and Pap and with Jim is that civilization plays the biggest part in it. While on the river with Jim they could just travel by themselves with the only contact with civilization comeing whenever they needed food or when they had to in the cases of the ferry boat captain, the Grangerfords, the King and Duke, and Uncle Silas and Aunt Sally. While with the Widow and Pap, Huck was in contact with civilization all the rime except when he wanted to get out of the Widcw's house to think or when Pap locked him up for a couple of days in the cabin while he went to town.

What it boils down to is that in comparing them they equalled in restraint and freedom pretty much but when contrasting them accorrding to contact with civilization, they were almost exact opposites. Huck didn't care for civilization so he took off and tried for the next best thing, floating down the Mississippi River with Jim as compared to complete isolation. Huck loved the river and loved adventure, he got both on the river where he wouldn't have gotten it living with the widow. I believe Huck made a wise choice when he decided to go his own way down the river.

Essay 2

Discuss and give examples of things in civilization that bothered Huck.

"I reckon I got to light out for the Territory ahead of the rest, because Aunt Sally she's going to adopt me and sivilize me and I can't stand it. I been there before."

This is what Huck has to say at the very end of the book. It certainly is clear by this statement that the idea of being "sivilized" bothered Huck. He's tried it but he didn't like it. What was it about being "sivilized" that bothered Huck?

It seems that a lot of the "sivilized" people that Huck has a close relationship with try to push their ideas and values onto Huck without giving him an explanation that is satisfactory to him. The Widow Douglas for example tries to get Huck interested in praying. Her explanation of prayer to Huck is that it's something that would get him whatever he asked for. Well, Huck tried it by praying for fish hooks and he didn't get anywhere. He told the Widow about his failure and she told him that he was a fool and left it at that. Religion is a part of civilization and Huck certainly couldn't see any sense in it after his experiences with prayer and his experience with the Grangerfords. He sat in church with the Grangerfords and listened to them praying and singing about brotherly love, while they were holding their guns between their knees.

Huck through his travels is able to see many faults in the way people are interacting with one another.

When Colonel Sherburn kills Foggs and is obviously in the wrong, Huck sees the whole town back down as Sherburn calls them a bunch of cowards.

When Huck sees the king and duck tarred and feathered he says "Human beings can be awful cruel to one another."

Huck has been out on the river and has lived also in the civilized world. On the river he has a sense of freedom which he can't experience while living in a "sivilized" manner. When he's out in the woods he often describes the beauty surrounding him. In towns he describes the cruelty and foolishness of the people that he sees.

It's no wonder that Huck wants to "light out for the Territory," after all of the things that he has seen during his travels. He has been able to compare civilization and nature and to him nature's good points outweigh those of civilization.

Essay 3

Compare and contrast Huck's life with the Widow Douglas and Pap with his life with Jim.

Living with the Widow, Pap, and Jim, Huck had three different life styles. This is mainly because these three people were completely different personalities and were of different social status.

Social status is a rather broad heading which is made up of smaller facets. Social status is decided by one's wealth, occupation, and to a certain extent, religion and manners. These facets can be identified in each of the characters Pap, Widow Douglas, and Jim. Once identified, it becomes possible to see why each lived as he did and how this then affected the way Huck lived.

The Widow Douglas lived in town and apparently was of a "respectable" class of society. Huck says that the Widow tried to "civilize" him. This included dressing him nicely, teaching him the Bible and religion, and teaching him etiquette such as grace before meals. Huck says that the Widow was "...regular and decent in all her ways..." (3) According to these ideas, Huck's opinion of the Widow is of a middle to upper social class.

Pap is something else. While the Widow urged neatness in dress, Pap was just the opposite. "His hair was long & tangled & greasy..." (17) "As for his clothes--just rags..." (18) Where the widow believed in education, Pap called it "foolishness." (18) He never had money and when he did he drank it away. Thus he was drunk a lot of the time. He really wasn't much of a father because all he did for Huck was beat him. He was far from a religious type. He could never hold a job, so he really amounted to little more than a bum. It can be seen then that Pap belonged to a lower class.

Jim is something else now. He has very little money, education, etc. In fact being a slave, he really has nothing whatsoever which might put him in a class of society. He was a slave and therefore even lower than the lowest social class of the white man's society. Being uneducated, his religion resulted in little more than a strong belief in superstition.

Living with these different people caused Huck to have to adapt to each. Living with Pap, Huck suffered the brutal life of frequent beatings, no care or attention, and no feeling between each other as human beings let alone father and son. Living with the Widow, Huck came a little closer to an emotional tie within a family type unit. The Widow tried to treat Huck good, and show him good. Even in the religion she taught. (11) Huck came to like the

Widow even though "he couldn't stand" being "sivilized" or living her way of life.

To Huck the median of these two life styles was life on the river with Jim. Here he was on his own as he had been with Pap, but he still had the human companionship and friendship he found at the Widows in Jim. Jim got along well with Huck because they could both live in an unsivilized manner. Huck was comfortable on the raft. He and Jim learned how to help each other and thus it was a give and receive type situation. Jim didn't dominate Huck's actions as the Widow might have nor did he treat Huck in the unfair way of Pap.

No matter what situation Huck lived in, he never lost his love for adventure or his bright imagination. At the Widow's, he still would sneak off with Tom to scheme and make adventures. Even with Pap, Huck kept his imagination going. This came in handy in helping him escape so successfully. And of course in going down the river with Jim, Huck used his imagination a lot not only to get them out of scrapes but into new adventures.

Huck's life styles differed in the way he dressed and lived. This decided by the social status of those he lived with. But his life style also was affected by the treatment he received from each person. However no matter the change, Huck always kept his imagination and love for adventure.

Essay 4

Compare Huck's life with Widow Douglas compared with his life with Jim.

Huck's life with Widow Douglas was much different than his life on the Mississippi with Jim. The river life was very romantic, while his life with the Widow was much more realistic.

While Huck lived on the river he had the romantic idealistic type life. How much more freedom could you have than traveling down the Mississippi on a raft? He had all of the elements of an ideal life: freedom, self-reliance, independence, and heroism. On the river Huck could live how he pleased and be individualistic. He could go back to nature and have an un-restrained life. This type of life is often romanticized and idolized. For example, Rousseau, whom we discussed in class looked upon the American Indians as noblemen living in a state of nature. Many novelists have glorified life on the frontier wilderness.

Jim represented freedom. Huck helped him achieve his independence and while he was helping Jim, he was also gaining his own independence. This freedom was a very important element, frequently mentioned about Huck's river life.

Besides having freedom on the river, Huckleberry Finn achieved a feeling of power. By doing things his way, he could influence what other people believed about him. The biggest example of this was when he fooled the entire town into believing he was dead, and then could attend his own funeral. I would be willing to bet a lot of people would want to watch their own funeral if they could! Life on the Mississippi was definatly a life Huck enjoyed, as he saw no sense in becoming "sivilized."

Huckleberry Finn's life with the Widow Douglas was much more realistic. Huck had to do what he was told, such as being well-mannered, and learning his lessons well. (He had to learn the multiplication table all the way up to $6 \times 7 = 35!$) During this time many realistic elements were present. Jim was their "nigger" slave and racism was evident. There was much ignorance in people in town. An example would be the many characters who were very superstitious. These were typically the uneducated people. Another example of realism was that Huck was not free to do everything he wanted when he lived with the Widow Douglas. Huck was different at the end living with Aunt Sally. He had changed much during his life of freedom on the Mississippi. He gained independence and individualism, characteristics frequently considered ideal.

Essay 5

Was Huck a changed person in the end? Explain.

By the end of the story I see that Huck has changed at least in two ways.

The first way I see is by age. In the beginning of the story Huck is about seven or eight. He has no mother, his father is off somewhere in the country drinking and gambling on what money he obtains. Huck is an orphan in this sense he lives in a empty hogshead or barrel. Huck doesn't go to school, he has not been civilized yet. After Tom and Huck found the money the Widow Douglas wants to "tame" Huck. He only agrees when Tom forms a band of robbers and will let Huck join if he stays with the Widow.

Next, I see Huck as a young boy, who has not matured. By the end of the story Huck is a young man. He still has an adventurous spirit. When Huck was young he was unruly and uneducated. By the end of the story Huck has settled down and he has been to school so he is educated a little.

Yes, Huck has changed. By the end of the story Huck is at least 14-15 years old. He has met people from all stages of life during his travels down the river. He has grown up both age and maturity. He is still a orphan but he has gained an insight into different stages of life and has learned by using his common sense.

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CHAPTER ELEVEN

The Impact of the ADAPT Program on the Teaching of Data Processing

by M.v.H. Hazen

My teaching has changed quite significantly over the last three semesters. Classroom time is no longer dominated by lectures with minimal discussion. Instead, the class is usually engaged in exploratory activities that lead to an invention and application phase, otherwise referred to as a learning cycle. A decreasing dependence on lectures as an instructional technique can be quite unsettling, particularly when the alternatives are not predefined by others. Therefore, during these past three semesters I have been undergoing as much if not more learning than my students have; and although the process that I underwent may have been arduous at times, the product which is emerging is a very satisfying and meaningful one for me as an instructor. I enjoy the increased interaction between my students and myself, and I enjoy watching the increased interaction amongst the students themselves.

I teach an introductory electronic data processing course for business students which consists not of freshmen, but of junior and senior level college students. I have been associated with the ADAPT program and instructors on an informal basis for the past three semesters and have gradually converted my class into a learning cycle format. This transformation has been guided by two Piagetian principles: first, that cognitive growth is developmental - in this case, that concrete operational thought precedes formal operational thought; secondly, that development from lower levels of reasoning to higher levels of reasoning occurs when a student is disequibrated and seeks to reorganize his knowledge via a self-regulatory process.

Piaget has provided a way for me to understand certain problematic situations. For example, in the past I found it extremely easy to misinterpret the level of student understanding. Concepts which appeared to be fairly easy from an instructor's point of view, have turned out to be difficult from the student's perspective. Although extra time would be devoted to these topics of difficulty, the class's understanding did not always improve. There were always some students for whom one-to-one tutoring (building the material in a very logical hierarchical manner) would

only result in further confusion and a state of frustration for both the student and the instructor.

I can now classify concepts which are commonly covered in an introductory data processing course as demanding either concrete operational or formal operational reasoning according to Piagetian criteria. For example, I have found that magnetic tapes, magnetic disks, punched cards, and paper tape can become concrete examples of computer hardware when they are brought into the classroom. An understanding of the concept "hardware" does not require formal reasoning; it involves only elementary classifications of objects that can be made readily accessible to a student. Most of the important information about hardware can be taught by referring to previously prepared tables and charts (for speed, capacity, cost, etc.), or by analogy to similar and more familiar devices such as sound recording tapes and phonograph records. No hypothetical reasoning is required for a basic understanding of this area of the course.

Aspects of computer software present a variety of more difficult concepts, however. Although computer programs are essentially instructions for a computer, they are difficult to work with because specification of storage usage and manipulation requires a higher or formal level of reasoning. Such reasoning bears little relationship to observable reality and works with multiple concepts so closely intertwined that it is difficult for a student to see cause and effect relationships within the total system. And yet, within the framework of the traditional introductory course, we ask many students to begin programming without a grasp of the concrete conceptual backgrounds which would facilitate the formal programming tasks.

The challenge is to somehow provide a concrete experience to facilitate assimilation of such formal concepts. Otherwise, the instructor must rely upon the student's prior experiences to carry the learner through the formal concepts. Under the traditional textbooks and lecture approach it was the student with an inadequate concrete experiential background who was most likely to do poorly. There was no way to reach him with words; even tutoring was not likely to help. Consequently, the major change that has taken place in my teaching has been to provide concrete experiences for formal concepts.

On a very elementary level, many students find it difficult to comprehend that the computer must be told what to do for them, and that it must be told what to do not only in a very specific and logical fashion but also in a predetermined language. To remedy this situation, students can be given an exploratory activity that asks them to devise a set of instructions for a clerk of very low intelligence. The clerk, who is ideal for repetitive routine

functions, performs only as well as the instructions he is provided with. The students are to see if they can provide instructions that will cause the clerk to update employees' salary figures by ten percent. These salary figures can be found in each employee's personnel folder residing in a file drawer.

Quite an interesting exercise develops when the instructor simulates the clerk and uses a file drawer as a prop. The instructions which are generated by the students encompass most of the COBOL language statements. It then becomes another exercise to transform these instructions into the actual given COBOL language. Thus the student is allowed to explore the concept of providing instructions to a computer and to invent his own series of appropriate COBOL language statements for this function. Discovery or application activities occur as these instructions, as well as similar ones, are implemented into a computer program. The learning cycle is thereby completed.

One of the most difficult aspects of the learning cycle is to find good, appropriate, and feasible concrete experiences. This is an even greater challenge for a course which is intended as an introduction to programming, systems analysis, and information systems - all in one semester. Nevertheless, some concrete experiences can be provided, particularly for the most difficult or formal concepts. One concept which I have watched students struggle with is the programming of master-transaction updating functions. This now standardized procedure has evolved over the last few years in response to large volume file maintenance needs. Students who have never experienced the need for efficiently processing large volumes of data therefore have no vested interest in the formal reasoning which such a process requires of them.

The student can, however, be given a simulated version of the problem. Using an example of a large file that he is likely to be familiar with (the local telephone listings, for example), an updating maintenance situation can be brought into the classroom. The student is first asked to look at and specify the process he might use for adding a few new names to the file; then he might be asked to consider the same problem for thousands of names. For the invention phase, he must again attempt to provide instructions in COBOL to a clerk of very low intelligence, and application or discovery will take place when these instructions are applied to actual computer problems.

Because the time pressures of my course do not allow for full implementation of the learning cycle in the classroom at all times, I ask the students on an individual basis to complete a simulated learning cycle in a written format. They choose an episode that may have occurred in the classroom or outside of it, reflect upon or hypothesize about this episode, relate this episode to theory or

other people's experiences, and then suggest applications of their findings to their future educational or occupational career. These papers have become a useful format for individual learning, student-instructor interaction, and evaluation.

The second aspect of Piagetian theory, self-regulation, is illustrated by another classroom situation that used to be problematic. My first approach was to begin the programming part of the course with lectures that presented the material in a very organized fashion. Ironically, however, it frequently appeared that the students learned how to program in spite of my instruction. No matter what the content or length or organization of my lectures were, the student was equally unprepared for the task of programming. Somehow the worth of these lectures decreased significantly as students came to me for answers to questions which arose during their programming efforts, answers that had been carefully covered in the prior classroom periods. Actually, since I was equally unprepared for my first programming effort (also after weeks of instruction), I did not really find this to be too unusual.

As Piaget would say, to know something is to act upon it. So now I request students to program (or modify a working program) with minimal if any preparation in the form of prior lectures. In theory, this should be an excellent self-regulating experience. In actuality, it can easily create unwanted anxiety in the student. It appears to the student to be a request far above his competency. Therefore, the instructor takes on a new role of facilitator of learning activities or even collaborator in the learning activities. He needs to establish a climate of mutual trust, one that is conducive to encouraging the usage of problem solving and reasoning processes.

When the student does however feel comfortable with this process of learning by doing (a process of constant questioning and checking out of hypotheses), self-regulatory mechanisms can readily be seen to be at work. The student is moving at his own pace and in his own manner from a lower level of reasoning to a higher level of reasoning by constantly comparing his hypotheses, his conjectures about computer logic, against the computer's actual logic.

The role of facilitator or collaborator was a totally new role for me. It has required time to develop a degree of comfort and skill with group processes. It is difficult not only for an instructor to change his role, but it is equally difficult for the students to adjust to this new situation. They express concern that they are expected to ask me and others questions (that is not what they had been led to believe from their prior experience), but they also express concern about working with other students on a

programming effort (they are used to independent efforts and competition). Some are also very concerned whether or not they are really learning something (there are no exams). All these concerns can and must be dealt with openly in or outside of the classroom.

In summary, there are three basic ways in which I have found the application of Piagetian theory to be helpful. First of all, the theory of cognitive growth has given me an understanding of students' reasoning processes that I did not have before. Secondly, the key concepts of my course (if eventually not all) have become easier to teach since they have been presented with a concrete experience as a base. Once you begin to think in terms of concrete experiences preceding the tasks or concepts that require formal reasoning, more and more activities will suggest themselves to you, and this in itself is quite an enjoyable and creative process.

Thirdly, self-regulated learning opportunities have the advantage of turning the student into a continuing learner. The content covered in my data processing course may have decreased, but the students' discussion and written work indicates that they have built a solid cognitive foundation and that the interests or unanswered questions stimulated by the course will encourage continual learning. For a field that is changing as rapidly as data processing is, this is a very desirable outcome.

CHAPTER TWELVE

Evaluation Report of the First Year

of the ADAPT Program

C. Tomlinson-Keasey, V. Williams, and D. Eisert

Evaluating the success of the ADAPT program seemed, at the outset, to be an extremely complex task. How does one assess a student's growth in six different content areas over a year's time? What are the hallmarks of progress which might signal the success or failure of the program? The first step of the evaluation was a clear enunciation of the goals of the program. In staff discussions it became clear that our primary goal was to encourage students to think critically and logically by devising a curriculum which required the students to actively participate in their learning and to explore substantive concepts within the six content areas. Secondly, we were interested in providing successful learning experiences that would facilitate personal and social growth. Finally, we hoped that students who were being encouraged to explore a variety of content areas would feel the excitement of learning and that this would be reflected in positive attitudes toward the whole university community. In short, our goals were to encourage abstract, formal thought patterns to facilitate personal growth and to cultivate positive attitudes toward the university.

Obviously, demonstrating that ADAPT students have changed on the above dimensions is not sufficient. Certainly one would expect some growth and change to occur during a college student's freshman year. A more compelling documentation of change requires that the ADAPT students' development be compared to some kind of standard of change. Hence two comparison groups of students were selected. The first comparison group was composed of students who had applied to the ADAPT program but in the random process of selection were not chosen as participants. These students enrolled in regular freshman courses at the University of Nebraska.

Later in the year it was decided that the freshman year for the ADAPT and control groups differed in so many ways that it might be helpful to have a third comparison group. A group of freshmen from the Centennial Education Program were selected as a third

comparison group. In this program, as in the ADAPT program, students are in small classes, they are encouraged to participate in class, they often know each other, and the professor usually knows them. Comparing this group to the ADAPT group seemed like a more reasonable test of whether the Learning Cycle (Karplus, 1974) as a curriculum organizer was effective in moving students toward more abstract thought processes.

Evaluation Instruments

To examine any changes in formal operational thought processes a series of paper and pencil tasks were devised. These were adapted from Inhelder and Piaget's (1958) original work in the area of formal operations. These tests examine the student's ability (a) to separate variables (b) to test variables in an unconfounded way (c) to generate hypotheses systematically (d) to display proportional reasoning (e) to conduct critical tests of hypotheses (f) to demonstrate an understanding of probability and (g) to ascertain the relationship between two variables. These tests of logical operations were administered to the ADAPT and Control groups at the beginning of the fall semester.

To examine personality changes and development in social areas, two tests were administered. In the fall the ADAPT and Control subjects were given the Omnibus Personality Inventory. This personality test emerged from the extensive work on college student development by Sanford (1956) and his associates at Vassar after World War II. Extensive data have been accumulated concerning this test by the staff of the Center for Research and Development in Higher Education at Berkeley. The test was selected because it examines both the intellectual and emotional aspects of personality. However, since it is more likely to indicate personality development over a long period of time, it was decided that it should not be administered a second time until the junior or senior year.

A test which is somewhat more likely to show short term changes is the Conceptual Complexity Assessment, conceived by Harvey, Hunt, and Schroeder (1961). This test deals with the adult's ability to conceptualize issues on succeeding abstract planes. Based on responses to sentence stems, a student is categorized into one of four stages. The lowest stage suggests that a student conceptualizes issues in black and white terms and is very concrete about the material and facts that are part of his clear cut and often simplistic handling of the issue. At the other end of the scale, a stage four response is characterized by a careful weighing of a variety of variables that effect the issue. The issue is conceptualized in much more abstract and general terms, and an attempt is made to look at all the variables that are relevant to the problem. The Conceptual Complexity Assessment was

administered to the ADAPT and Control subjects in the fall and to all three of the freshman groups in the spring.

Finally to assess the students' attitudes toward various facets of University life the College Student Questionnaire Part II was administered. This standardized attitude questionnaire is published by the Educational Testing Service. A student's responses to the multiple choice questions are summarized into scores on eleven dimensions. These include a look at (a) how the student perceives his family and his peers, (b) the student's perception of the society in general, (c) the student's satisfaction with the University environment, and (d) how the student balances studying with extracurricular involvements. All three of the freshman groups responded to this test during the spring semester.

Initial Measures

In order to compare the effects of the freshman year on the three target groups--ADAPT students, control students and Centennial students--it was first necessary to assess the students on some measure taken prior to their entrance to the University. The American College Testing (ACT) program administered nationally provides such a measure. Table 1 shows the relative positions of the three groups as well as the means and standard deviations of the entire freshman class at the University of Nebraska-Lincoln on the ACT. While some slight differences did occur, the three groups appear essentially equivalent on this measure. Several other variables that allow a comparison of the three groups of Freshmen are presented in Table 2. It is interesting to note that the ADAPT group has a larger percentage of instate students than any of the other groups. Also, the ADAPT group has by far the largest percentage of students who graduated from the bottom half of their class (34.8%). In the control group a very large percentage of students had graduated in the top quarter of their high school class.

Assessing Formal Operational Thought

The basic design of the evaluation of formal thought was a pretest and posttest comparison of the ADAPT and Control groups. Since the Centennial group was not added until the spring of the year, no pretest scores were available on those students.

Table 3 presents the means and standard deviations of the ADAPT and Control subjects on eight subtests of formal operations and a composite index of formal operational ability. The ADAPT students scored significantly higher than the Control students on

three of the subtests and on the Composite index. Both groups made significant improvements during the year on (a) systematically generating combinations, (b) using a logical strategy to help them generate combinations, (c) conducting critical tests and (d) solving correlation problems. These results suggest that the freshman year is a time of intellectual growth for all students, but that the ADAPT students made progress over and above that typically seen during the freshman year.

There is a hazard to this analysis, however, since the ADAPT students scored significantly higher on the pretest than the controls. To control for any bias this might have introduced, it was decided to look at the performance of a group of ADAPT students who were matched with Control students on pretest scores. Such a matched pairs analysis showed that the ADAPT students gained an average of 3 more points than the Control students on the posttest $t(19) = 3.38, p < .01$. This difference would be expected to occur by chance less than one time in one hundred. This somewhat truncated sample indicates that the ADAPT students are learning how to think abstractly and perform formal operations at a pace that is not matched by the Control students.

The Centennial students' scores on the posttest are compared with the ADAPT and Control groups' scores in Table 4. It is evident that a substantial difference exists between groups on five of the eight subtests. The ADAPT students score higher than the other groups on four of the five subtests and their superiority to the other two groups on the composite score is clear.

Assessing Conceptual Complexity

The formal operations tests administered and described above concentrate on logical, systematic, and deductive kinds of thought processes. The analysis of these tests indicated that, in general, the ADAPT students evidenced more of these characteristics after their freshman year than the other two groups. There is, however, more to adequate conceptual functioning in American Society than logical, deductive abilities. In fact other investigators have argued that personality development and the development of social skills are the critical acquisitions of the college years.

As the year progressed, the ADAPT students showed marked changes in personality skills and the level of their social interactions. It was hoped that the conceptual complexity measure would provide a more systematic documentation of the staff's subjective impressions that many such changes were occurring.

Table 5 shows the means and standard deviations of the three groups on the conceptual complexity measure. Comparing only the

ADAPT and Control students, we see a slight downward shift during the year in the Control students. The ADAPT students on the other hand show a substantial increase resulting in a significant interaction $F(1, 52) = 6.68, p < .02$ between the two groups and the pretest and posttest. A comparison of all three groups on the posttest shows that both the ADAPT and Centennial students scored significantly higher on this measure than the Control subjects.

Since growth in this area is seen as a function of interpersonal skills, it is appropriate to ask what characterizes the ADAPT and Centennial students that might facilitate such growth. One possible answer is that both groups are in social clusters. The ADAPT students attend all of their classes together. Many of the Centennial students live in the dormitory associated with the Centennial Education program. Unlike the Control students, the ADAPT and Centennial students interacted together in class settings as well as outside of class. Perhaps it is the depth of the social interaction with another group that fosters conceptual growth.

Other differences that may be very influential in fostering conceptual complexity are the small classes and the concomitant level of interaction with professors. Perhaps this kind of personal interaction encourages students to conceptualize issues in a more differentiated and abstract way.

Assessing Attitudes Toward College

One of the critical components of the freshman year seems to be the student's attitude toward school. In fact, positive or negative attitudes about their college experience are often critical factors in whether students decide to drop out of school or remain in it. For this reason the attitudes of all three groups of students were assessed on the College Student Questionnaire Part 2. The scores for the three freshman groups in the present study and a sample of 1500 freshmen and sophomores from a variety of colleges and universities are presented in Table 6.

One can't help but note the satisfaction with faculty scores. Here the ADAPT students are clearly more satisfied with their instructors than the Centennial students $t(55) = 2.08, p < .05$. Two scales on which the ADAPT students score lower than the other groups are cultural sophistication and satisfaction with their major. The latter score is understandable in terms of the large number of undeclared students in the ADAPT program.

Summary

An overall summary of the first year of the ADAPT program indicates that the program has been moderately successful at achieving its goals. ADAPT students made significantly more gains in the realm of logical and abstract thinking than a matched group of Control students. In addition, there is evidence that during the year they learned to conceptualize issues in a more differentiated way than the Control subjects. Further, their attitudes toward social and academic experiences are quite favorable and they appear to have gained satisfaction from their interactions with both faculty and students. These changes are especially encouraging when one considers that over one-third of the ADAPT students were from the bottom half of their graduating class. The documentation of change along these dimensions has given rise to cautious optimism that the ADAPT program may facilitate the kind of logical, abstract thinking that is so prized in our society.

TABLE 1

Means and Standard Deviations
of Freshman Groups on ACT

	ACT <u>Composite</u>	<u>English</u>	<u>Math</u>	<u>Social Science</u>	<u>Natural Science</u>
All Freshmen at UN-I n = 2,747	21.95 5.13	19.53 4.75	22.78 6.88	20.88 6.82	24.15 5.93
ADAPT n = 27	21.29 4.94	18.85 4.99	20.85 6.93	21.29 5.78	23.81 5.81
Control n = 27	24.25 3.77	21.29 3.91	25.54 3.85	23.13 6.28	26.54 4.83
Centennial n = 19	21.89 5.01	20.05 4.95	21.05 5.68	21.89 5.86	24.68 6.19

TABLE 2

Percentages of Freshmen in Each Group

	% from Nebr.	% from out of state	% from Lincoln & Omaha	% from rural Nebr.	% in each quarter of high school class			
					top	2nd	3rd	4th
UNL- Freshman	93.16	6.84	52.57	47.43	47	33	14	6
ADAPT	96.80 n=30	3.20 n=1	60.00 n=18	40.00 n=12	47.8 n=11	17.4 n=4	26.1 n=6	8.7 n=2
Control	92.00 n=23	8.00 n=2	52.2 n=12	47.8 n=11	73.9 n=17	17.4 n=4	8.7 n=2	
Centen- nial	90.32 n=28	9.68 n=3	60.7 n=11	39.3 n=17	41.7 n=10	37.5 n=9	8.3 n=2	12.5 n=3

TABLE 3

Means and Standard Deviations on Formal Operations Measures

		ADAPT (n=32)		Control (n=26)		2x2 ANOV	
		Pre- test	Post- test	Pre- test	Post- test	Group	F Time F
1.	No. Produced (16)	12.34 3.20	13.91 2.96	9.73 4.71	11.88 3.84	8.06**	12.56**
2.	Initial Marks Held Constant (15)	5.31 3.52	7.91 4.82	3.92 3.25	4.42 3.35	9.11**	6.35*
3.	Drawing Con- clusions (4)	2.63 1.64	2.75 1.67	2.92 1.29	2.46 1.53	<1	<1
4.	Critical Tests (4)	2.00 1.68	2.81 1.51	1.69 1.76	2.23 1.81	1.32	9.44**
5.	Probability (6)	4.69 1.69	5.03 1.57	4.88 1.33	5.42 1.10	<1	3.77
6.	Correlation (16)	9.19 5.16	10.59 5.01	7.23 4.97	8.42 4.97	3.17	3.95*
7.	Separating Variables (8)	5.94 1.72	5.87 1.79	5.69 2.09	6.19 .94	<1	<1
8.	Holding Variables Constant (4)	3.03 1.49	3.38 1.24	3.38 1.36	3.46 1.03	<1	<1
9.	Composite Formal Operations Score Total possible=73	45.28 12.71	52.34 11.99	38.92 10.63	44.50 9.92	6.72*	23.85**

*probability level <.05

**probability level <.01

TABLE 4
Posttest Only Comparisons of Three Freshmen Groups
On Formal Operations Measures

	<u>ADAFT</u> n=32	<u>Control</u> n=26	<u>Centennial</u> n=32	<u>F</u>
Number Produced (16)	13.91 2.96	11.88 3.84	9.66 5.40	8.16**
Initial Marks Held Constant (15)	7.91 4.83	4.42 3.35	3.22 2.61	13.45**
Drawing Conclusions (4)	2.75 1.67	2.46 1.53	1.44 1.78	5.40**
Critical Tests (4)	2.81 1.51	2.23 1.82	2.12 2.49	1.09
Probability (6)	5.03 1.58	5.42 1.10	4.69 2.35	1.21
Correlation (16)	10.59 5.01	8.42 4.97	7.53 5.98	3.17*
Separating Variables (8)	5.88 1.79	6.19 .94	5.31 1.60	2.54
Holding Variables Constant (4)	3.38 1.24	3.46 1.03	3.06 1.24	<1
Composite Formal Operations Total Possible = (73)	52.34 11.99	44.50 9.92	36.97 13.29	13.07**

*probability level <.05

**probability level <.01

TABLE 5
Means and Standard Deviations of Three Groups
on Conceptual Complexity

	<u>ADAPT</u> n=128	<u>Control</u> n=26	<u>Centennial</u> n=30
Pretest	1.69 .45	1.73 .36	
Posttest	1.907 .36	1.612 .41	2.13 .998

TABLE 6
Means and Standard Deviations of Groups
on College Student Questionnaire Part II

	<u>ADAPT</u>	<u>Centennial</u>	<u>Control</u>	<u>National Sample</u>
Family Independence	22.23 4.70	23.41 6.03	20.46 4.50	22.16 5.24
Peer Independence	24.41 4.21	24.29 3.60	23.35 3.32	23.98 4.12
Liberalism	27.60 3.61	29.38 4.39	25.50 3.50	25.86 4.65
Social Conscience	29.13 4.78	30.13 5.23	29.15 5.32	27.98 4.71
Cultural Sophistication	20.68 4.18	25.06 4.74	21.65 4.30	23.51 5.31
Satisfaction with Faculty	28.60 4.64	25.69 5.65	26.81 4.78	25.27 4.69
Satisfaction with Administration	25.55 4.55	23.22 5.50	26.81 3.55	26.33 5.26
Satisfaction with Major	20.50 2.50	25.42 4.59	29.71 4.10	27.55 4.56
Satisfaction with Students	26.80 3.33	25.69 3.67	25.72 3.81	26.83 4.49
Study Habits	23.44 5.32	24.69 4.43	25.38 4.79	25.22 4.35
Extracurricular Involvement	20.63 3.99	18.00 5.01	20.85 4.96	20.84 4.46

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CHAPTER THIRTEEN

Assessment of Proportional Reasoning of Adapt and

Other Students

T.C. Campbell

The operation of proportional reasoning is a prerequisite skill required for science and mathematics. Do college age students easily evoke and utilize this skill? Since proportional reasoning is basic to many of the tasks described in the book by Inhelder and Piaget, The Growth of Logical Thinking from Childhood to Adolescence (Basic Books, N.Y., 1958), it provides a logical basis for this assessment.

The clinical interview format employed by Inhelder and Piaget requires a considerable time commitment. This restriction usually prohibits the assessment of either a large number of students ($N > 500$) on a single task or a moderate number of students ($N < 100$) on a variety of tasks. In addition, the use of the Piagetian tasks has been open to the interpretation of the researcher using them. This means that in using the tasks to assess cognitive skills, the methods employed by the researchers seldom reproduce exactly those utilized by Inhelder and Piaget.

This suggests that a variation in assessment procedures from the strict clinical interview method may be appropriate. Such a variation could reduce the time restriction discussed above and still allow reference to the original work of Inhelder and Piaget. The lifting of this restriction could allow for the assessment of a moderate number of students ($N < 100$) on a wide variety of operations and/or a large number of students ($N > 500$) on a single operation. This paper describes an attempt to develop and utilize a written instrument for assessing the cognitive ability for a large number of students on a single operation, proportional reasoning.

The written instrument consists of two proportional reasoning puzzles placed on two sides of a single piece of paper. The metric puzzle asks a simple proportional conversion from miles to kilometers. Two road signs, the first complete, gives the following information: Cleveland 94 miles; 152 kilometers. The

second road sign is incomplete, given, Wahoo _____ miles; 380 kilometers. Students are asked to complete the missing information in the second sign and to "explain in words" how they calculated the result.

The more advanced apartment puzzle shows a scale drawing of a "modular apartment building". In the same scale a single cubic module and a smaller vacant lot are shown. Students are asked to find the height of a new building to be constructed on the same modular design and of the same number of modules. Open blanks are provided for the students to explain the reasoning they used to determine the height of the new building. Reduced copies of the instruments are shown on the following page.

Although no direct reference to the Piagetian state of intellectual development is made in the response levels, one can easily provide some rationale for this extrapolation. The levels of response may be grouped into five categories. These categories can be related to the concrete operational (C), formal operational (F), and a mixture of concrete and formal operations which we call Transitional (T).

Metric Puzzle

Students who reason at the concrete level will attempt this problem by adding and subtracting the numbers as they look for a way to equate proportions. These students usually fail to find a satisfactory solution or simply give a guess.

Students who are at the transitional level of reasoning will attempt to use proportional reasoning but invert the ratio or fail to cross multiply correctly.

Students who have reached the formal level of reasoning have little difficulty in finding the solution. The percentage of the students who utilize the form $A/B = C/D$ is about the same as those who find a ratio, A/B , and then multiply by D .

Apartment Puzzle

The puzzle was developed out of a need to further differentiate the use of proportional reasoning in the sample. The added features of this puzzle such as measurement, volume, and area complicate the use of proportional reasoning. It seems that students must be very familiar and confident in the use of the proportional reasoning operation to solve the apartment puzzle.

Students whose reasoning is at the concrete level rely on the visual interpretation of clues provided by the drawings. Students who do not conserve volume have little chance of solving the

problem.

Other students focus their attention on measuring the pictorial objects. The application of proportional reasoning is not completed at this state because of failure to exclude all the irrelevant variables and use measurement, conservation of volume, and proportional reasoning at the appropriate times.

At the formal stage of reasoning, students begin to relate all three important factors: measurement, conservation of volume, and proportional reasoning.

This written instrument was used to collect proportional reasoning data from a total of 545 college students. These data include University of Nebraska students and community college students from Illinois, North Carolina, and Florida.

A profile of proportional reasoning skills of university and community college students is shown in Figure 1. The proportional reasoning of students in two selected University of Nebraska anthropology and history classes is distributed by college year against percentage of class in each of three groups: F-Formal, T-Transitional and C-Concrete. This reasoning profile for university students indicates a uniform development of the operation of proportional reasoning. It seems clear that continued success in college requires the use of proportional reasoning. Evidently, students are developing this skill and/or the university system is "weeding" them out before they become upperclassmen.

Thirty-six adult students enrolled in a vocational refrigerator-air conditioning course at William Rainey Harper Community College also participated in the study. The responses given by students were also categorized as F, T, and C and are also shown in Figure 1.

A developmental model for proportional reasoning is suggested. The adult data show a definite shift of students from the Transitional to Formal operational group and provides an excellent extension of the university data. The trend shown by Figure 1 certainly agrees with Piaget's developmental hypothesis. It is somewhat surprising that proportional reasoning is delayed until such a late age.

During the first semester of 1975, the instruments described above were used in a pretest-posttest format. At the beginning of the fall semester, pretests were given to 28 students enrolled in the experimental ADAPT program. Following a semester of instruction, each student completed a post-test. Instruction during the semester was based upon the Piagetian model of intervention called The Learning Cycle (see Chapter 2).

Following the pretest, students were grouped into three categories; Formal, Transitional, or Concrete, by assignment of a score based upon the sum of the metric puzzle score and the apartment puzzle score.

An analysis of variance was used to determine the significance of the change which occurred in the pretest-posttest comparison. This analysis showed that students in the lower two groups (Transitional and Concrete) made significant gains in the use of proportional reasoning at the .01 level of confidence. Figure 2 illustrates the initial and final distribution of students' scores on the pretest and the posttest.

Figure 2 was constructed to show the change in student scores from pretest to posttest. The basis of the diagram is a hierarchical arrangement of the range of scores actually achieved by students. These scores are given as an ordered pair, (score on metric puzzle, score on apartment puzzle) and are arranged in ascending order of proportional reasoning skill. For example, the arrow in the table marked with an asterisk shows a student who scored (2,1) on the pretest moving to a score of (4,1) or (5,1) on the posttest.

These results suggest that the ADAPT program has been effective in helping students evoke formal characteristics in the use of proportional reasoning. The nonsignificant change made by the formal group reflects an expected "ceiling effect" which is characteristic of the written test. The percentage of ADAPT students in each category for the pretest and for the posttest is shown in Figure 1 with the distribution of other UNI students. It is interesting to note that the ADAPT group's distribution following the pretest looked similar to the sophomore distribution

and the posttest distribution was nearly identical to the senior distribution.

A significant result of this study is the indication of the development of the proportional reasoning operation in college students. One could argue that a larger fraction of senior students operated formally because the concrete operational students were no longer in school; the adult data suggest that this may be true only in part. None of the adults were college graduates, yet displayed the largest percentage of formal operations. This suggests that maturity and life situations are providing appropriate disequilibrating experiences for the further development of many important mental operations like proportional reasoning.

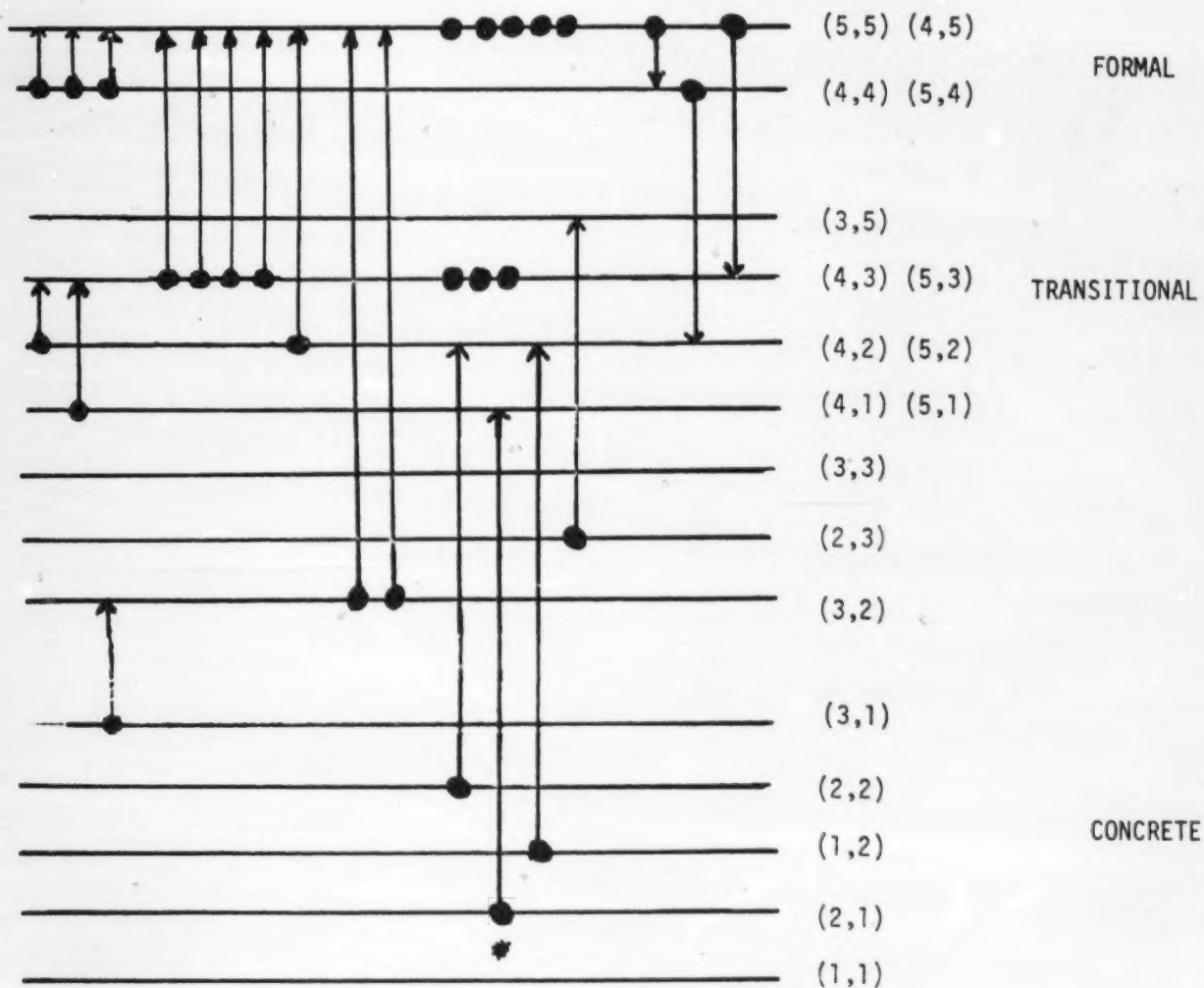


FIGURE 2. Change in student scores from pretest to posttest.

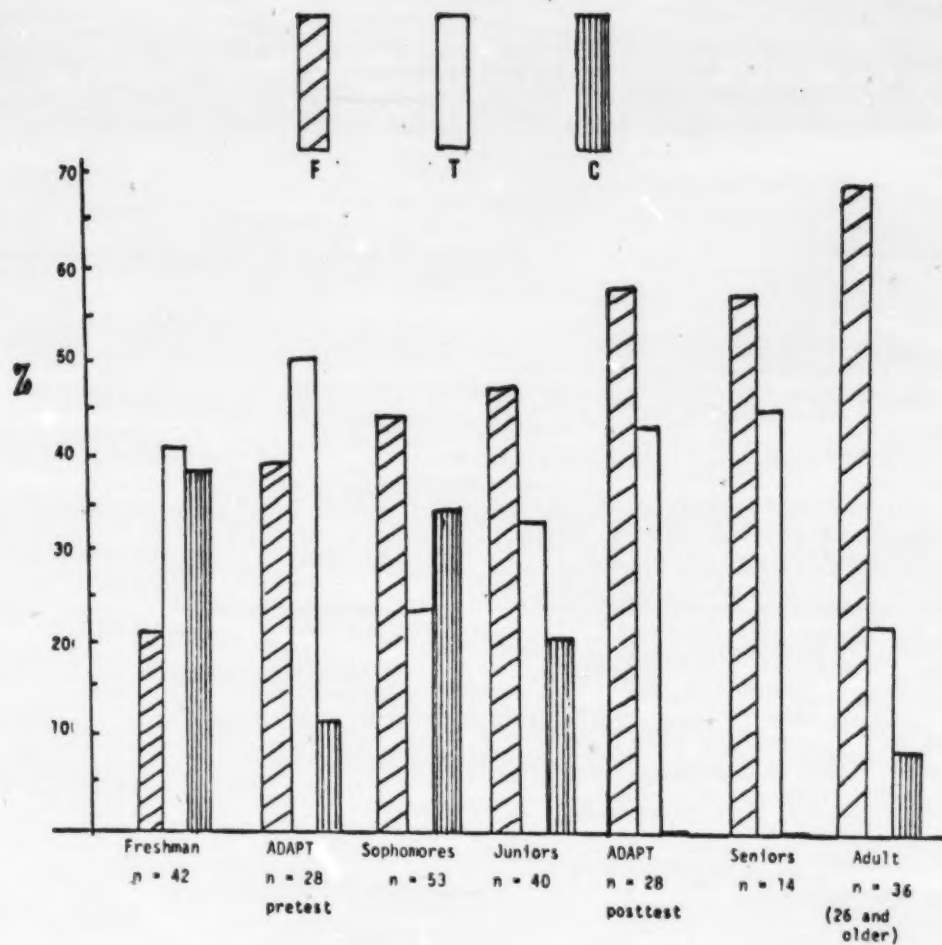


Figure 1

Epilogue

You have had a chance to read about the ADAPT program. The presentations in this book are as varied as the styles of the people who participated in the ADAPT project. Amidst all of this variety of information, you may be wondering just what the essential features of the ADAPT program really are. Is it essential to have six different disciplines in the program? Does it make any difference which six disciplines you choose? Do evaluating psychologists play a key role in such a project? There are, I believe, two necessary conditions for starting an ADAPT-type program.

First, you must find a core group of first-rate, tenured faculty members who are willing to participate in the project. The necessity for tenure for the project staff persons arises because the additional effort required to work in an ADAPT-like program is likely to take time away from other scholarly activities upon which most promotion and tenure decisions are based. First-rate faculty members, by my definition, will have the following characteristics.

(1) Professional competence in their disciplines. Faculty persons unsure of their own professional competence may not be willing to depart from the orthodox procedures of their disciplines. ADAPT staff persons spend time in such activities as counting play money and watching glass beads roll off the edge of a table. These are hardly activities designed to impress professional colleagues. Only persons who feel "OK" in their disciplines will be free to risk large departures from the usual behavior of college professors.

(2) Concern for student learning and willingness to try alternative instructional strategies. These two attributes need to be combined in an ADAPT staff person. Sometimes professors decry the poor performance of the students in their courses. Professors who respond to poor student performance by lecturing more slowly and/or putting fewer questions on examinations are unlikely candidates for an ADAPT project. Professors who have countered student learning difficulties with tutorials, or small group work, or role playing, simulation and game activities, or repeatable testing, or Keller Plan instruction, etc. are much more likely to make an effective contribution to an ADAPT program.

(3) Evidence of having heard a student's questions. Most of the instructional strategies mentioned above will personalize the relationship between the professor and the student. In such a relationship the professor can really hear a student's own authentic questions. Upon hearing real student questions, a concerned professor may become aware, at least subconsciously, that some students live in a special world. For these students all

answers are either right or wrong. For them actions and motives are either good or bad. Their books and poems have a correct meaning. Their history is primarily a collection of facts and dates. Their economics and anthropology are pre-causal, e.g., lower state taxes and lower state university tuitions in a general inflationary period are compatible, and human behavior just happens. Their thinking in mathematics and physics includes neither proportional nor propositional reasoning.

On the basis of all these experiences, a first-rate faculty member may perceive that the fundamental cause of poor student learning is not low mastery of course content but is a narrow, rigid student world view. Now this faculty person is prepared to participate in an ADAPT-type project.

The second necessary condition is for the core group to undertake a program to study the theory and research related to a scheme for understanding student development. In guiding this study program the evaluation psychologists can make a valuable contribution to the project. Neither learning theory nor educational psychology seem to have high professional prestige in the more traditional university disciplines. Some professors who have a perception of the student world view mentioned above may not be willing to seek new insights into solving the problem of poor student learning in their discipline by studying some other discipline. The ADAPT staff began by studying the research on and theory of cognitive development reported by Jean Piaget and his collaborators. The staff reviewed attempts to practicalize Piaget's work into curricula and instructional strategies, particularly the work of Robert Karplus and in his co-workers in the Science Curriculum Improvement Study. Then the ADAPT staff modified those concepts and strategies to fit their college teaching in their separate disciplines. The ability of the ADAPT staff to work together creatively was increased by their commitment to risk trusting in Piagetian psychology and trying "Karplusian" learning cycles. Such a common commitment is, I believe, a necessary condition for the successful functioning of a multidisciplinary program for college freshmen.

In summary, there are two necessary conditions for beginning an ADAPT-like program, a first-rate, tenured core group of faculty and a common basis in a scheme for understanding student development. Are these conditions also sufficient to assure the long life of pioneer ADAPT-type programs in the frontiers of higher education? If information about ADAPT-type programs is widely shared, then in a few years perhaps an answer can be given to this question.

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